



Missouri
Department of
Natural Resources

Biological Assessment and Stressor Report

Miami Creek Bates County, Missouri

Fall 2006

Prepared for:
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

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1.0 Introduction

Approximately 18 miles of Miami Creek were included in the 2002 Missouri 303(d) list for sediment impairment due to agricultural non-point sources (**AgNPS**). This prompted a biological assessment to be conducted on Miami Creek, Bates County in 2003-2004. Five stations were used to assess the potentially impaired area (MDNR 2004). The stations were spaced at approximately 3-5 mile increments, ranging from just northwest of Butler, Missouri to one mile upstream of the confluence with Marais des Cygnes River, approximately four miles north of Rich Hill, Missouri (MDNR 2004).

In the 2003-2004 biological assessment, three of the five stations sampled in the fall were found to be fully supporting the protection of aquatic life designated use (**AQL**- MDNR 2005c), while two were partially supporting the AQL (MDNR 2004). All stations were fully supporting in the spring of 2004.

1.1 Justification

The Missouri Department of Natural Resources (**MDNR**) Total Maximum Daily Load (**TMDL**) acceptable support ratio (i.e. full support: partial & non support) for impaired streams should equal or exceed the support ratio of reference streams in the same Ecological Drainage Unit (**EDU**). The cumulative support ratio for stations on Miami Creek in the 2003-2004 study was 80:20, while the support ratio for reference streams in the Central Plains/Osage/South Grand EDU was 82:12.

According to the MDNR Sediment TMDL Sediment Strategy, a stressor study must be conducted on a stream with acceptable habitat conditions that does not meet or exceed the acceptable support ratio for its EDU. Stream habitat conditions were acceptable in the 2003-2004 study, so a stressor study (Appendix A) was written for Miami Creek and was conducted in the fall of 2006. The stressor study includes additional macroinvertebrate community and water quality assessment, additional dissolved oxygen studies, a benthic fine sediment study, and a channel morphology evaluation.

The Miami Creek stressor study was conducted at the request of the Missouri Department of Natural Resources (**MDNR**), Water Protection Program (**WPP**), Water Pollution Control Branch (**WPCB**). The Environmental Services Program (**ESP**), Water Quality Monitoring Section (**WQMS**), Aquatic Bioassessment Unit (**ABU**) coordinated and conducted the study.

1.2 Purpose

Collect additional data concerning impairment and potential water quality stressors of Miami Creek.

1.3 Objectives

- 1) Assess the macroinvertebrate community integrity and water quality of Miami Creek.

- 2) Determine if benthic sediment affected the stream habitat quality.
- 3) Determine if channelization had an affect on the stream habitat quality.

1.4 Null Hypotheses

- 1) Macroinvertebrate communities are similar to biological criteria and index scores between reaches of Miami Creek from upstream to downstream.
- 2) Water quality is similar from upstream to downstream and with the reference stream.
- 3) Dissolved oxygen concentrations are similar between reaches of Miami Creek from upstream to downstream and to Little Drywood Creek; and acceptable to water quality standards (MDNR 2005c).
- 4) Benthic sediment volume is similar between reaches of Miami Creek from upstream to downstream and to Little Drywood Creek (control).
- 5) Channel width, depth, and sinuosity measures are similar between reaches of Miami Creek from upstream to downstream and to Little Drywood Creek (control).

2.0 Methods

Methods are outlined in this section. The study area and station descriptions, Ecological Drainage Units (**EDUs**), and land uses are identified. The study timing is outlined. Biological assessment procedures, which include macroinvertebrate community and physicochemical water collection and analyses, are discussed.

Kenneth B. Lister (ESP), Brian Nodine (ESP), and other members of the WQMS conducted this study.

2.1 Study Area and Station Descriptions

The study area included the 18-mile TMDL 303(d) listed segment (Figure 1). Stations used in 2006 were the same five stations included in the 2003-2004 study (Table 1; Figure 2). One station was allocated for Little Drywood Creek, Vernon County as a control for benthic fine sediment and channel morphology comparisons.

2.1.1 Ecological Drainage Unit

Miami Creek is located within the Central Plains/Osage/South Grand EDU (Figure 1). Ecological Drainage Units are delineated drainage units that are described by the physiographic and major riverine components. Similar size streams within an EDU are expected to contain similar aquatic communities and stream habitat conditions. Comparisons of biological and physicochemical results between test streams and similar size reference streams within the same EDU should then be appropriate.

Table 1
 Location and Description of Miami Creek, Bates County Stations and Little
 Drywood Creek #1, Vernon County

Stream-Station Number	Location-Section, Township, Range/Latitude and Longitude	Description	County
Miami Creek #5	SW ¼ sec. 13, T. 40 N., R. 32 E. Lat. 38.279642 Long. -94.426033	Downstream confluence Butler City Lake spillway	Bates
Miami Creek #4	SE ¼ sec. 24, T. 40 N., R. 32 E. Lat. 38.258300 Long. -94.405726	Downstream MO Hwy 52	Bates
Miami Creek #3	NW ¼ sec. 6, T. 39 N., R. 31 E. Lat. 38.221346 Long. -94.380443	Downstream CR bridge, 2 miles west of 52/71 junction	Bates
Miami Creek #2	SE ¼ sec. 8, T. 39 N., R. 31 E. Lat. 38.176898 Long. -94.352835	Downstream US Hwy 71	Bates
Miami Creek #1	SW ¼ sec. 15, T. 39 N., R. 31 E. Lat. 38.161882 Long. -94.328986	Downstream CR 1.5 miles east of US Hwy 71	Bates
Little Drywood Creek #1, (Sediment and Channel Control)	SE ¼ sec. 30, T. 35 N., R. 31 W. Lat. 37.785800 Long. -94.390080	Upstream bend in CR 515E	Vernon

CR=County Road

2.1.2 Land Use Description

Land use near the Miami Creek stations was compared between stations, Little Drywood Creek, and the Central Plains/Osage/South Grand EDU using a 14-digit Hydrological Unit scale (**HUC-14**; Table 2). Percent land use data were derived from Thematic Mapper (TM) satellite land cover data collected between 2000 and 2004 and interpreted by the Missouri Resource Assessment Partnership (**MoRAP**).

Land use was similar between Miami Creek stations, Little Drywood Creek, and with the Central Plains/Osage/South Grand EDU (Table 2). Little Drywood Creek and the Plains/Osage EDU contain slightly more forest land cover than either of the two Miami Creek HUC-14 drainages. General land use should not interfere with interpretation of the results.

Table 2
 Percent Land Cover in Miami Creek, Bates County; Little Drywood Creek, Vernon
 County; and the Central Plains/Osage/South Grand EDU

Stations	HUC-14	Urban	Crops	Grass	Forest	Wetland	Open- water
Miami Creek #5, #4	10290102120004	1	29	58	6	2	1
Miami Creek #3, #2, #1	10290102120006	2	28	53	8	5	0
Little Drywood Creek #1	10290104060002	2	22	54	12	7	1
Central Plains/ Osage/South Grand EDU	NA	3	28	44	14	--	--

HUC-14=14-digit Hydrologic Unit Code; EDU=Ecological Drainage Unit

2.2 Study Timing

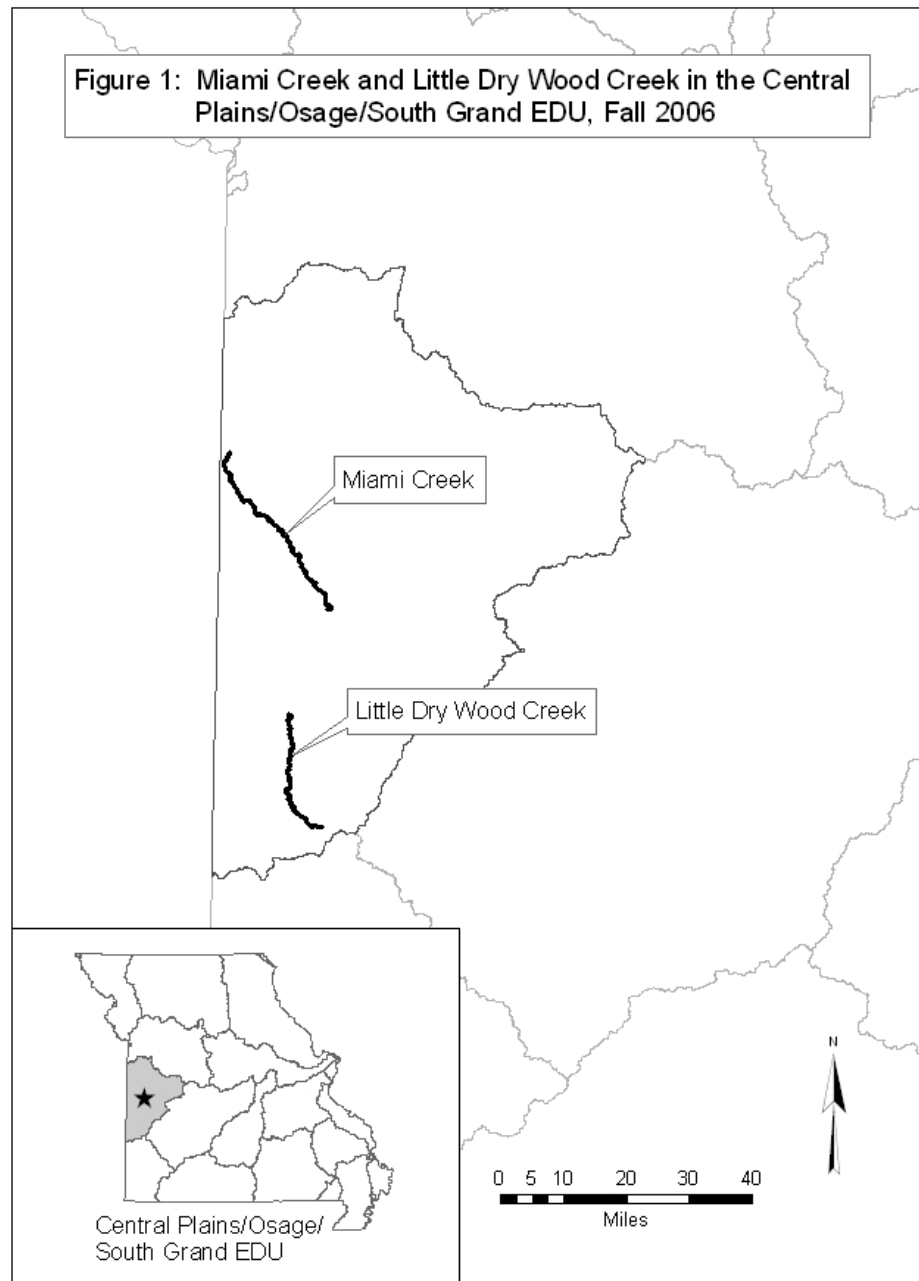
The study took place in 2006. Macroinvertebrate and water sampling occurred October 4. Discrete dissolved oxygen measurements were recorded on July 25 and 28. Channel measurements were recorded September 12 and 13 at Miami Creek and September 25 at Little Drywood Creek. Benthic sediment sampling took place on September 12 and 13.

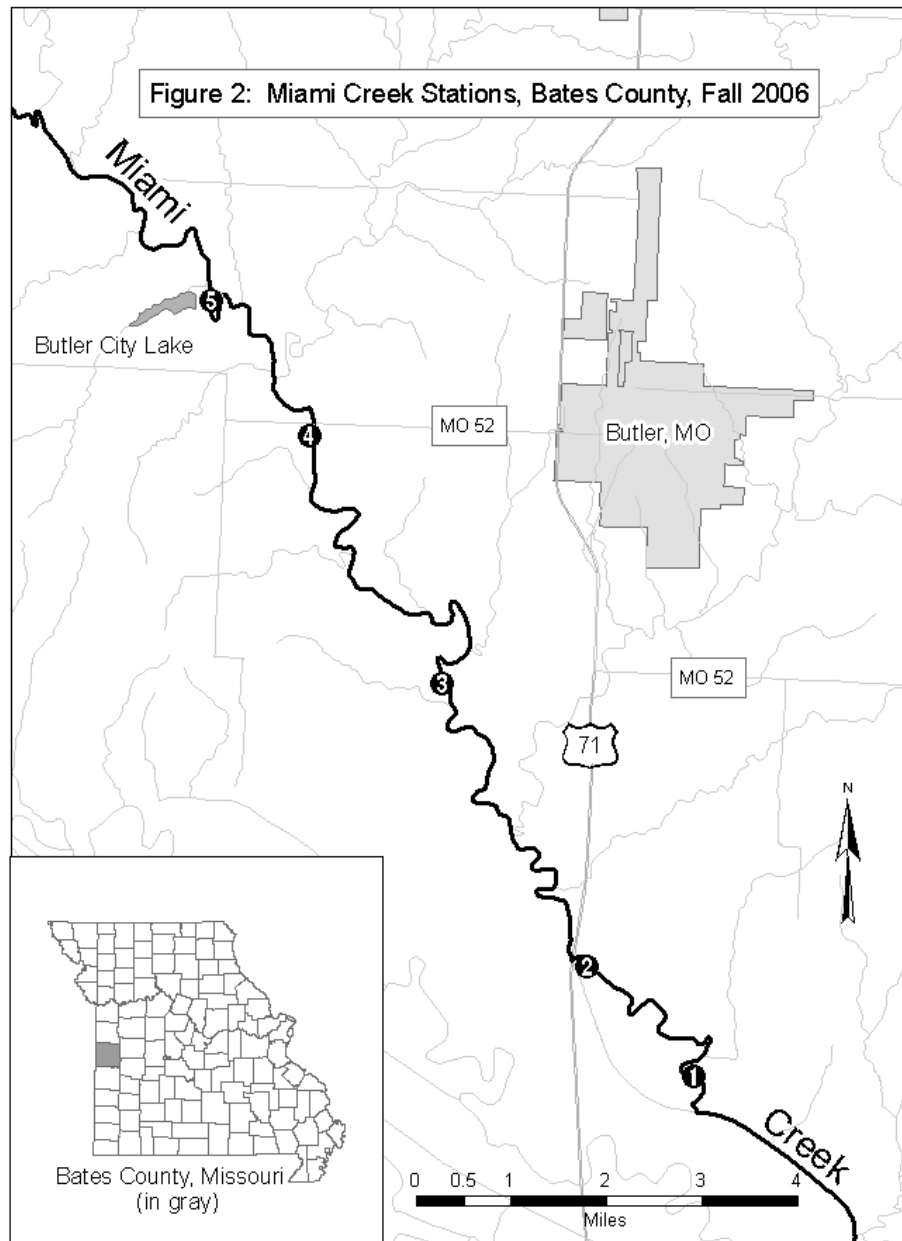
2.3 Biological Assessment

Sampling was conducted as described in the MDNR Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP, MDNR 2003d). A biological assessment consists of macroinvertebrate community and physicochemical water evaluation.

2.3.1 Macroinvertebrate Sampling and Analyses

As identified in the SMSBPP, macroinvertebrates were sampled from three specific habitats. Target habitats are identified based on stream type (MDNR 2003d). Miami Creek is considered a glide/pool dominant stream in which depositional substrate (**NF**), snag (**SG**), and rootmat (**RM**) habitats are sampled. Macroinvertebrates were subsampled according to the SMSBPP and identified to specific taxonomic levels (MDNR 2005b) in order to calculate metrics using a standard method (MDNR 2003d; MDNR 2005b).





Macroinvertebrate community data were analyzed using three strategies. Macroinvertebrate Stream Condition Index (**MSCI**) scores, individual biological criteria metrics, and dominant macroinvertebrate families (**DMF**) were examined and compared from upstream to downstream.

The first strategy is based on the MSCI. A Stream Condition Index is a qualitative measurement of a stream's aquatic biological integrity (Rabeni et al. 1997). The MSCI was further refined using additional information from biological reference streams (**BIOREFs**) within each EDU in Biological Criteria for Perennial/Wadeable Streams (MDNR 2002; MDNR 2003d). A station's MSCI score is a compilation of rank scores that are assigned to the primary biological criteria metrics. The four primary biological criteria metrics are: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). An individual metric score is compared to its BIOREF scoring range (MSCI Scoring Table, Tables 4 and 5) and a rank score (5, 3, or 1) is assigned to that metric (Tables 4 and 5). This is repeated for each of the four metrics and rank scores are compiled to complete the MSCI score. Biological integrity is based on the MSCI scores and is interpreted as follows: 20-16 = full biological support; 14-10 = partial biological support; and 8-4 = non-support of the biological community (MDNR 2003d). MSCI scores were grouped by season and compared between stations.

A second measure to evaluate the macroinvertebrate community examined individual biological criteria metrics. Each individual metric was compared to the BIOREF scoring range to identify the level of integrity for each station. Variations in the metrics may help identify how a community is affected and potentially identify a source of impairment.

The third biological analysis was an evaluation of the taxa that occur in each station. Dominant macroinvertebrate families (**DMF**) are compiled as a percentage of the total number of individuals in a sample. Dominance by certain families may identify the quality of the station and help identify a type or source of impairment.

A taxa list is attached as Appendix B and is grouped by season and station from upstream to downstream.

2.3.2 Physicochemical Water Sampling and Analyses

Physicochemical water samples were handled according to the appropriate MDNR, ESP Standard Operating Procedures (**SOP**) and/or Project Procedures (**PP**). Results for physicochemical water parameters were examined by station.

Fall 2006 physicochemical water parameters were either sampled by field measurements or collected as grab samples. Water was sampled according to the SOP MDNR-FSS-001 Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2003c). All samples were kept on ice during transport to ESP.

Water samples were either measured *in situ* or analyzed at the Environmental Services Program laboratory. Temperature (C°), pH, conductivity (uS), dissolved oxygen (mg/L), and discharge (cubic feet per second-**cfs**) were measured in the field. Turbidity (NTU) was measured and recorded in the WQMS biology laboratory. Analyses for ammonia-nitrogen (mg/L), nitrate + nitrite-nitrogen (mg/L), total nitrogen (mg/L), chloride (mg/L), and total phosphorus (mg/L) were conducted by the ESP, Chemical Analysis Section (**CAS**) in Jefferson City, Missouri.

Physicochemical water parameters were compared between stations from upstream to downstream, as well as with Missouri's Water Quality Standards (**WQS**, MDNR 2005c). Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and its beneficial use designation (MDNR 2005c). Miami Creek is a class "P" stream, with designated uses for Livestock and Wildlife Watering, Aquatic Life Protection, and Whole Body Contact-Category B. Furthermore, acceptable limits for some parameters, such as dissolved metals, may be dependent on the rate of exposure. These exposure or toxicity limits are based on the lethality of a toxicant given long-term exposure (chronic toxicity, **c**) or short-term exposure (acute toxicity, **a**).

2.3.3 Mid-Summer Dissolved Oxygen and Temperature Observations

Oxygen sensing dataloggers were placed at stations #5, #3, and #1 for long-term monitoring (3 days) of dissolved oxygen according to MDNR SOP 2003a. First, three dataloggers were deployed at station #3 and measurements were taken in close proximity with a hand-held dissolved oxygen meter to serve as a quality control between dataloggers. Second, measurements were recorded during deployment and retrieval of dataloggers to determine their accuracy. Third, dataloggers were again deployed and measurements were recorded from all three deployed in one location to determine consistency. The datalogger recordings were not consistent between each other at the single location and were not similar with the discreet recordings taken at that time, the time of deployment, or of retrieval. The dataloggers failed to provide accurate or repeatable data and therefore those results are not included in this report.

The discreet dissolved oxygen measurements from the datalogger deployment are included in this report along with temperature data at each station. Dissolved oxygen measurements were recorded with a hand held field meter as directed in the MDNR-SOP-103 (MDNR 2002b) and temperature was recorded from datalogger records. Dissolved oxygen and temperature measurements were collected from stations #5, #3, and #1 on two days. Station #3 is shown twice for both the deployment day and the retrieval day. The station was also used for quality control between dataloggers, as well as for individual datalogger deployment and retrieval recordings. Stations #5 and #1 were sampled once per day. Deployment day was July 25, 2007 and retrieval day was July 28, 2007.

Dissolved oxygen measurements were recorded at Little Drywood Creek, Vernon County and compared with Miami Creek measurements. One measurement was taken at two stations on Little Drywood Creek: LDW#1 - upstream of county road 515E

(Latitude 37.785800, Longitude -94.390080); LDW#2 - downstream of NW 100th road (Latitude 37.652400, Longitude -94.386380). These additional dissolved oxygen and temperature measurements may help identify typical conditions of the stream related to a reference stream.

2.3.4 Discharge

Stream flow was measured using a Marsh-McBirney Flowmate™ flow meter at each station. Velocity and depth measurements were recorded at each station according to SOP MDNR-WQMS-113 Flow Measurement in Open Channels (MDNR 2003b).

2.4 Benthic Fine Sediment

Benthic sediment was collected using a sampling method under development by the WQMS (see Appendix A; Attachment A). Sampling occurred at ten transects within each station. Analysis of the fine sediment utilized a modified Bouyocos (1962) Soil Texture Method for Sediment Analysis. All five Miami Creek stations were sampled to measure the quantity of benthic fine sediment per station. Little Drywood Creek #1 was used as a control. The data were examined for similarities between all stations, as well as with the control station. Further data analysis included statistical comparisons of benthic fine sediment using SigmaStat, Version 2.0 (1997).

2.5 Channel Measurements

Channel measurements were recorded to illustrate the size and shape of the stream and potentially identify past channelization (MDNR 2005a). These measurements included channel width, wetted width, and depth measurements in the channel. Channel measurements were recorded at ten transects per station. Channel width (**cw**) included the entire channel measured at the top of the lower bank. Wetted width (**ww**) included the channel width that contained water. The depth (**d**) of the stream was measured at three locations ($\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ of the wetted width) in each transect. Stream length was the length of the reach used in this study, which is approximately 20 times the average channel.

Sinuosity is a ratio of the actual distance to straight line (aerial) distance. The center of the station was determined on a 7.5-minute topographic map. The actual distance was traced from the center following the stream to a distance of one mile upstream and one mile downstream; points were drawn at the upstream and downstream locations. The straight line distance was calculated between those two points. The formula was actual distance divided by the straight line distance.

2.6 Quality Control

Quality control was conducted in accordance with MDNR Standard Operating Procedures (**SOPs**). Macroinvertebrate community and water physicochemical variables were duplicated at Miami Creek station #1 (e.g. 1A and 1B). Ten percent of the benthic fine sediment samples were duplicated from randomly selected transects.

3.0 Results and Analyses

Results are compiled for stream habitat assessments, biological assessments, physicochemical water parameters, dissolved oxygen and temperature measurements, benthic sediment, and channel measurements. Results of the biological assessment, including physicochemical water parameters, were compared from upstream to downstream stations. Additional dissolved oxygen studies, benthic sediment, and channel measurements are compared with results from Little Drywood Creek #1, a reference stream in the EDU. Stream habitat assessment results are generally included, however, were reported in the Miami Creek Biological Assessment of 2003-2004 (MDNR 2004).

3.1 Stream Habitat Assessment Project Procedure

The Miami Creek, Bates County Biological Assessment Report (MDNR 2004) suggested that the stream habitat at these Miami Creek stations were comparable to the reference stream. Scores at all stations exceeded 75 percent of the mean of SHAPP controls (MDNR 2003e). The quality of stream habitat should not influence the results in this biological assessment.

3.2 Biological Assessment

A biological assessment consists of macroinvertebrate community analyses and physicochemical water parameter analyses. Results are grouped by season and station.

3.2.1 Macroinvertebrate Community Analyses

Evaluation of the macroinvertebrate communities in Miami Creek involved application of the qualitative MSCI, individual metrics, and examination of dominant macroinvertebrate families. Macroinvertebrate community analyses are based on results from the fall 2006 sample season.

3.2.1.1 MSCI

The Macroinvertebrate Stream Condition Index (MSCI) scores for the fall 2006 sample season identified one station with partial support of AQL category and the remaining four stations in the full support category (Table 3). Station #5 received an MSCI score of 14, which indicates some impairment to the community. Stations #4 and #2 had the highest scores, 18 and 20 respectively, while all others received a full support score of at least 16.

3.2.1.2 Individual Metrics

Examination of the individual metrics identify why MSCI scores are less than optimum (Table 3). Miami Creek #5 TR, EPTT, and SDI were below the optimum BIOREF scoring range. Station #4 had a BI that was slightly above the optimum BIOREF scoring range. Station #3 had an EPTT that was below and the BI was slightly elevated. Stations #2 and #1(A and B) had optimum BIOREF scores for all of the individual metrics. It appears that stations #5 and #3 were composed of more biologically stressed communities, although #3 was not scored as impaired.

Table 3
 Fall 2006 Biological Criteria (BIOREF) Metric Scores, Biological Support Category, and
 Macroinvertebrate Stream Condition Index (MSCI) Scores for
 Miami Creek Stations, Bates County

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Miami Creek #5	0602745	39	3	7.67	2.56	14	P
Miami Creek #4	0602750	69	11	7.75	3.18	18	F
Miami Creek #3	0602749	63	6	8.08	2.91	16	F
Miami Creek #2	0602748	68	11	7.65	3.37	20	F
Miami Creek #1A	0602746	66	9	7.59	3.38	20	F
Miami Creek #1B	0602747	75	10	7.54	3.42	20	F
BIOREF Score=5		>55	>6	<7.73	>2.84	20-16	Full
BIOREF Score=3		55-28	6-3	7.73-8.86	2.84-1.42	14-10	Partial
BIOREF Score=1		<28	<3	>8.86	<1.42	8-4	Non

MSCI Scoring Table (in light gray) developed from BIOREF streams (n=13); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

3.2.1.3 Dominant Macroinvertebrate Families

The top five dominant macroinvertebrate families showed similarity between stations from upstream to downstream (Table 4). Chironomidae was the dominant family present at all stations. Tubificidae, Caenidae, and Hyalellidae were among the top five dominant taxa present at most stations. The percentage of Chironomidae and Tubificidae decreased at #4, #3, and #1.

The invertebrate database bench sheet report showed a difference in the number of generally sensitive taxa, such as Trichoptera and Ephemeroptera, from upstream to downstream stations (Appendix B). No Trichoptera and three Ephemeroptera were found in station #5. Station #4 had the most EPT with six Trichoptera and five Ephemeroptera taxa. Station #3 decreased to only one Trichoptera genus, yet had five Ephemeroptera taxa. Station #2 had four Trichoptera and seven Ephemeroptera taxa, while #1 had three Trichoptera genera and at least six Ephemeroptera taxa.

Table 4
 Top Five Dominant Macroinvertebrate Families (DMF) as a Percentage of the Total
 Number of Individuals per Station at Miami Creek, Fall 2006

Station	#5	#4	#3	#2	#1A	#1B
Sample Number	0602745	0602750	0602749	0602748	0602746	0602747
Chironomidae	47.6	46.1	52.8	31.1	29.1	29.0
Tubificidae	16.2	10.1	12.5	7.0	8.6	6.5
Caenidae	9.8	11.8	--	8.8	10.2	10.3
Hyalellidae	8.5	8.6	12.1	16.5	--	--
Arachnoidea	6.6	--	5.0	--	--	--
Scirtidae	--	5.4	2.8	--	--	--
Corbiculidae	--	--	--	7.5	--	--
Sphaeriidae	--	--	--	--	8.1	8.2
Coenagrionidae	--	--	--	--	6.0	8.9

3.2.2 Physicochemical Water Analyses

Physicochemical water analyses identified interesting trends in the fall 2006 sample season (Table 5). Seven parameters exhibited trends, most in similar stations. Only trends from each season are highlighted. One parameter was not within the acceptable range for WQS (MDNR 2005c).

Conductivity was elevated throughout the entire study area, however, it fluctuated from upstream to downstream (Table 5). Conductivity increased over 200 mg/L between station #3 to #2. Conductivity reached a high of 672 uS at station #2. Conductivity decreased over 200 mg/L from #2 to #1.

Discharge fluctuated from upstream to downstream (Table 5). Station #5 had no measurable flow. Discharge increased and reached a sample high of 0.35 cfs at station #4 before lowering to 0.08 cfs at #3. Discharge increased at #2 to 0.32 cfs before dropping slightly to 0.30 cfs at #1.

Dissolved oxygen concentrations fluctuated from upstream to downstream (Table 5). Station #5 was less than 1.0 mg/L and increased over five-fold at station #4. Levels dropped to approximately 1.5 mg/L at #3 and rose again at #2 to a high of 7.6 mg/L. Dissolved oxygen levels lowered to 2.23 mg/L at station #1. Dissolved oxygen concentrations were below acceptable WQS at #5, #3, and #1 (MDNR 2005c).

Nitrate+nitrite as nitrogen (-N) concentrations fluctuated from upstream to downstream (Table 5). Nitrate+nitrite-N was not detected at #5. It was found at 0.12 mg/L in #4. Station #3 had nitrate+nitrite-N below detection limits. Station #2 had the highest concentrations at 4.84 mg/L. Nitrate+nitrite-N was not detected at station #1.

Total nitrogen was detected at all stations in the fall (Table 5). Total nitrogen levels reached a high of 5.81 mg/L at station #2, which was approximately four-fold higher than other stations.

Ammonia levels decreased from upstream to downstream (Table 5). Ammonia was highest (0.74 mg/L) in the station #5 water sample. It was detectable (0.06 mg/L) at station #4 and not detected at the remaining downstream stations.

Chloride concentrations fluctuated from upstream to downstream (Table 5). Chloride concentrations increased approximately seven-fold from station #5 to #4. Levels dropped nearly 30 percent from #4 to #3. Chloride concentrations doubled to a high of 79 mg/L at #2 and decreased to 30.2 mg/L at #1.

Table 5
 Physicochemical Water Parameters, Miami Creek Stations, Fall 2006

Station	Miami Creek #5	Miami Creek #4	Miami Creek #3	Miami Creek #2	Miami Creek #1A / #1B
Parameter / Date	10-4-06	10-4-06	10-4-06	10-4-06	10-4-06
Sample Number	0607293	0607298	0607297	0607296	0607294 / 0607295
pH (Units)	7.60	8.00	7.70	8.00	7.60
Temperature (C ⁰)	20.0	24.0	21.0	23.0	20.0
Conductivity (uS)	430	399	451	672	467
Dissolved O ₂	<1.0	5.88	1.51	7.60	2.23
Discharge (cfs)	0.0	0.35	0.08	0.32	0.30
Turbidity (NTUs)	9.57	3.69	11.0	3.23	6.21 / 10.3
Nitrate+Nitrite-N	<0.01	0.12	<0.01	4.84	<0.01 / <0.01
Total Nitrogen	1.94	0.77	0.72	5.81	0.61 / 0.60
Ammonia-N	0.74	0.06	<0.03	<0.03	<0.03 / <0.03
Chloride	7.42	51.1	37.5	79.0	30.2 / 30.3
Total Phosphorus	0.20	0.02	0.16	0.11	0.11 / 0.12

(Units mg/L unless otherwise noted; **Bold**=out of WQS acceptable range or trend)

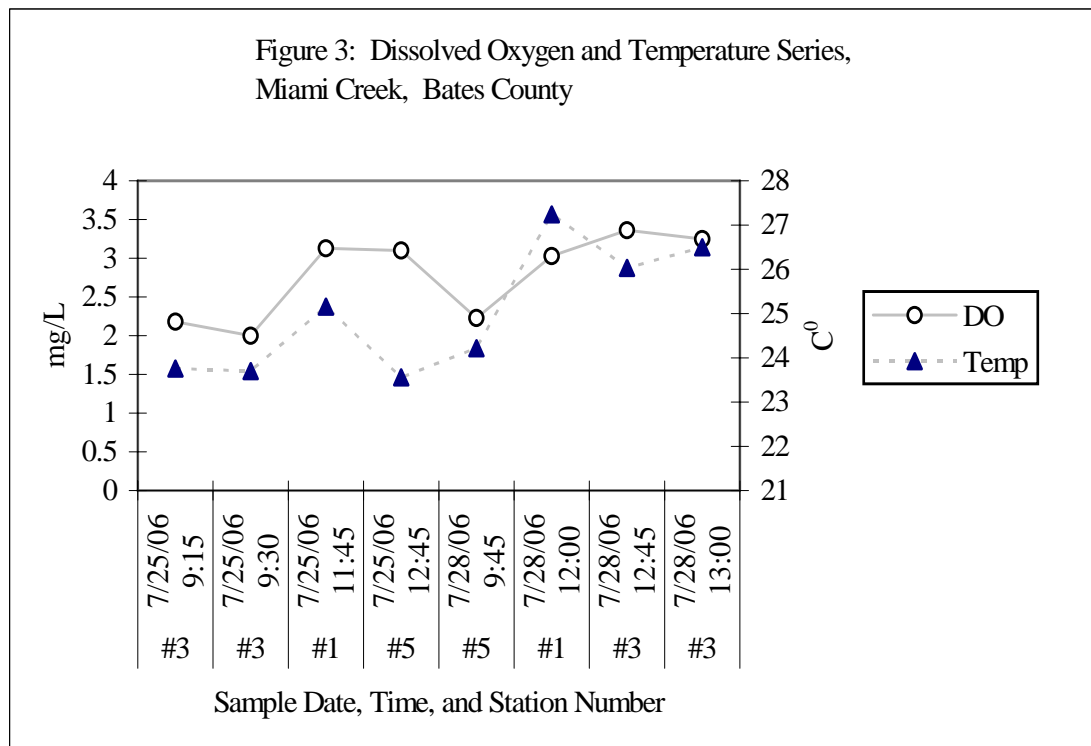
3.2.2.1 Mid-Summer Dissolved Oxygen and Temperature Observations

Discreet dissolved oxygen and temperature measurements were taken at stations #5, #3, and #1 on Miami Creek (Table 6; Figure 3). On July 25, 2006, dissolved oxygen measurements ranged from 2.0 mg/L at 09:15 to 3.13 mg/L at 11:45 across all stations. On July 28, 2006, dissolved oxygen ranged from 2.23 mg/L at 0:945 to 3.36 mg/L at 12:45 between all stations. Temperature ranged from 23.70 to 25.16 C⁰ on deployment day, with the range on retrieval day between 24.22 to 27.24 C⁰. Additional dissolved oxygen measurements recorded at Little Drywood Creek on September 25, 2006 revealed 6.42 mg/L from station #1 at 13:45 and 3.64 mg/L from station #2 at 17:20. Water temperature was 17 C⁰ at both stations. All dissolved oxygen concentrations measured during the summer were below WQS (MDNR 2005c).

Table 6
Discreet Dissolved Oxygen and Temperature Measurements at Three Stations on Miami Creek, July 25 and 28, 2006 (See Figure 3)

Date/Time Station	July 25, 2006				July 28, 2006			
	09:15	09:30	11:45	12:45	09:45	12:00	12:45	13:00
Miami Creek #5	--	--	--	3.10/ 23.56	2.23/ 24.22	--	--	--
Miami Creek #3	2.18/ 23.88	2.00/ 23.70	--	--	--	--	3.36/ 26.03	3.25/ 26.79
Miami Creek #1	--	--	3.13/ 25.16	--	--	3.03/ 27.24	--	--

Dissolved oxygen measurements=mg/L / Temperature=C⁰



3.2.3 MSCI Scores/Flow/Dissolved Oxygen

Stations #5 or #3 contributed to the sub-optimal cumulative MSCI support ratio (Table 7a). Station #5 had the greatest influence on MSCI scores for both studies since two of the three sub-optimal scores were contributed by #5. These two account for 13 percent of the 15 total samples. Station #3 contributed a single sub-optimal score in the fall of 2003.

Interestingly two physicochemical parameters, discharge and dissolved oxygen, appear to follow a similar trend as the MSCI at these two stations (Tables 7a and 7b). Station #5 only partially supported the aquatic life designated use and had no measurable flow in the fall of 2006. Station #5 again only partially supported the aquatic life designated use in the fall of 2003 and likewise had no measurable flow. Station #3 only partially supported the aquatic life designated use in the fall of 2003 and had the second lowest flow of the season.

Dissolved oxygen followed a similar trend at #5 and #3 (Tables 7a and 7c). Station #5 in fall 2006 had the lowest dissolved oxygen concentration (0.78) of the season. Stations #5 (3.8 mg/L) and #3 (2.93 mg/L) had the lowest dissolved oxygen concentrations of the fall 2003 season. Station #3 had low flow and dissolved oxygen in fall 2006 yet was supporting.

Table 7a
 MSCI Scores at Miami Creek Stations and Support Ratio

MSCI Scores	Fall 2003	Spring 2004	Fall 2006
Miami Creek #5	10	16	14
Miami Creek #4	16	16	18
Miami Creek #3	14	16	16
Miami Creek #2	16	16	20
Miami Creek #1	16	16	20
Support Ratio	60:40	100:0	80:20

20-16 Full support; 14-10 Partial support (bold); (n=15) biological support across all seasons=80:20; Acceptable support ratio for Central Plains/Osage/South Grand EDU=82:18 (2007); Fall 2003 and Spring 2004-Courtesy MDNR 2004

Table 7b
 Discharge (cubic feet per second) at Miami Creek Stations per Season

	Fall 2003	Spring 2004	Fall 2006
Miami Creek #5	0	29.8	0
Miami Creek #4	1.77	41.9	0.35
Miami Creek #3	0.06	52.7	0.08
Miami Creek #2	0.88	95.8	0.32
Miami Creek #1	0.81	81.6	0.30

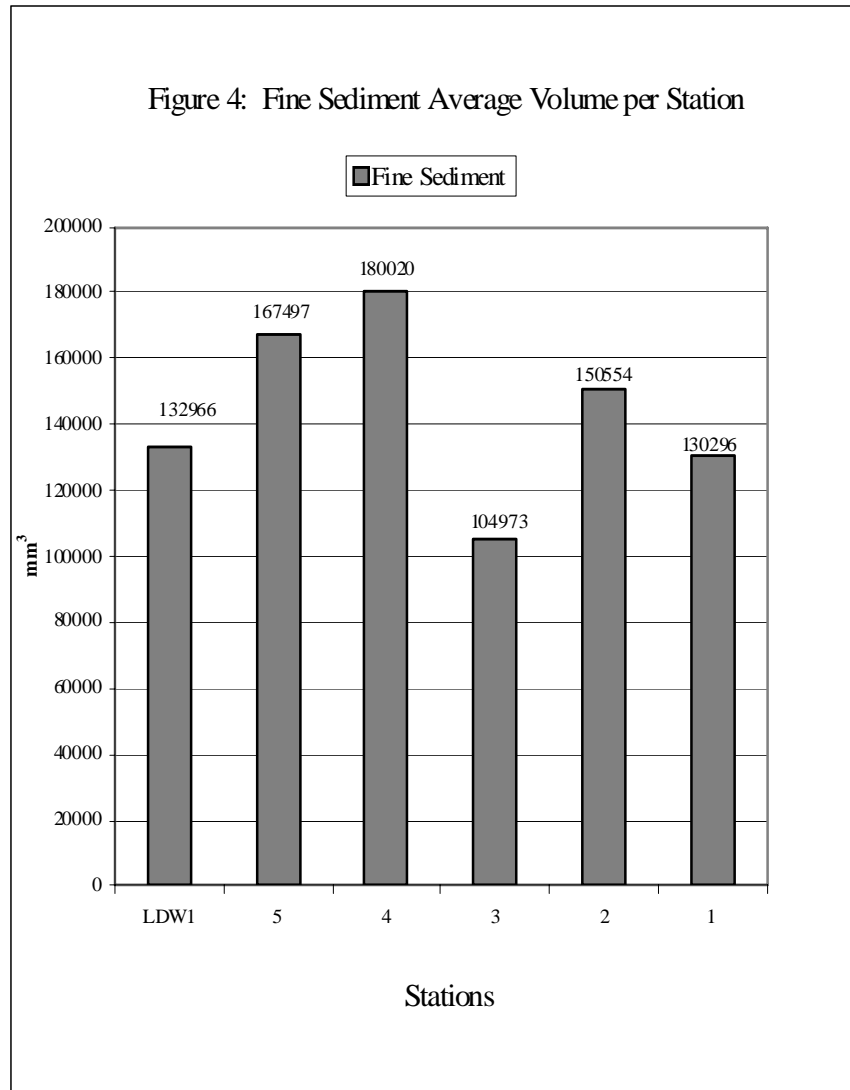
Table 7c
 Dissolved Oxygen Levels (mg/L) at Miami Creek Stations per Season

	Fall 2003	Spring 2004	Fall 2006
Miami Creek #5	3.8	12.6	0.78
Miami Creek #4	6.12	12	5.88
Miami Creek #3	2.93	10.9	1.51
Miami Creek #2	4.6	11.3	7.6
Miami Creek #1	4.8	10.6	2.23

WQS=5.0 mg/L

3.3 Benthic Fine Sediment

The quantity of benthic fine sediment at Miami Creek was similar between stations and to the control stream Little Drywood Creek (Figure 4). Station #4 had the largest amount with 180,020 mm³, while #3 had the lowest quantity at 104,973 mm³. One way ANOVA between all stations and with the control illustrated no significant difference (P=0.236; D.F.=5) from upstream to downstream or between the test and control station (Appendix C).



LDW1=Little Drywood Creek

3.4 Channel Measurements

Channel measurements were examined from upstream to downstream and compared to the control stream (Table 8). Channel measurements were similar from upstream to downstream with the exception of the cw/ww ratio. The ratio indicated the water in the Miami Creek channel was bank to bank at most locations. Miami Creek channel widths

were narrower than the control and wetted widths were wider than the control (Table 8). The ww/d ratio potentially identified a wide shallow stream, which was not supported by the depth data. The stream was deeper at all stations, except #1, with greater variation in depth (standard deviation) at all stations. The maximum depth was greater at Miami Creek. Stations #4 and #2 were slightly less sinuous than the remaining stations and the control.

Table 8
 Channel Measurement Information for Miami Creek and
 Little Drywood Creek Stations, 2006

STATION VARIABLE	Miami Creek #5	Miami Creek #4	Miami Creek #3	Miami Creek #2	Miami Creek #1	Little Drywood Creek #1
Channel Width average (cw)	29.9	30.0	27.3	35.2	38.6	48.1
Wetted Width average (ww)	27.7	28.9	25.9	31.7	28.0	21.48
cw/ww	1.08	1.04	1.05	1.11	1.38	2.24
ww/d	22.4	18.83	16.87	20.83	29.29	20.04
Depth Average (d)	1.24	1.54	1.54	1.52	0.96	1.07
Depth Standard Dev.	0.57	0.62	0.66	0.90	0.68	0.49
Maximum Depth	2.58	2.60	2.80	3.08	2.67	2.15
*Sinuosity	1.97	1.17	1.56	1.26	1.85	1.56
Sinuosity (Actual) Length	3186	3273	3150	3216	3247	3224

* Sinuosity=Actual vs. Straight Line Distance Ratio; Units=Feet

4.0 Discussion

The discussion highlights the impaired station and interesting trends in scores and water quality from upstream to downstream. The quantity of benthic sediment and channel morphology is compared to the control stream.

4.1 Impaired Station: #5

Of the five stations in this study in the fall of 2006, station #5 was considered to have partial support of the AQL. The community at #5 had approximately half the taxa richness of all other stations with less than half the number of sensitive taxa (EPTT) at

most stations and with a less diverse and less even community than all other stations. Station #5 had no Trichoptera and only three Ephemeroptera taxa, compared to at least six EPTT at downstream stations. The dominant taxa were chironomid and tubificids at station #5, which decreased by half at station #2. These clearly indicated there was stress on the system at station #5 in the fall of 2006. All other stations were fully supportive of the macroinvertebrate community.

This is similar to findings in the fall of 2003 where #5 again showed only partial support of the macroinvertebrate community (MDNR 2004). In the spring of 2004, #5 was not impaired based on MSCI scores, which suggests that stress is not continuous.

4.1.1 Water Quality Station #5

Two related parameters appear to be associated with the low scores at station #5. Station #5 had no measurable flow and had the lowest dissolved oxygen concentration of all stations in 2006. Historically, flow and dissolved oxygen were low when station #5 failed in 2003. Dissolved oxygen was below WQS (MDNR 2005c) in 2006 and 2003. Conversely, station #5 has passed when flow and dissolved oxygen were higher, which suggested that the two parameters are related to scores. Also, ammonia was found in low levels, probably due to near anoxia and decomposition in the pooled station.

4.2 Trends: Upstream to Downstream

Flow and dissolved oxygen fluctuated from upstream to downstream. Station #5 was pooled with low dissolved oxygen measurements. Flow and dissolved oxygen increased at Station #4. Station #3 flow decreased to nearly zero and dissolved oxygen decreased significantly from upstream. Station #2 increased to the highest flow and in turn dissolved oxygen increased to its highest level. Flow at station #1 was much lower than #2 and dissolved oxygen followed the same trend. Other water quality parameters, which are constituents of wastewater and water treatment, were found at Stations #4 and #2. Although discharge was not measured at the outfalls, the source of increased flow was assumed to be from the Butler water treatment facility and wastewater treatment facility. This flow apparently had an effect, as macroinvertebrate scores also fluctuated from upstream to downstream.

Macroinvertebrate index scores fluctuated from upstream to downstream following a very similar trend. Station #5 failed, while the scores at #4 increased significantly. Station #3 narrowly passed and #2 reached the optimum BIOREF score. Station #1 also had a perfect score. Fluctuations in MSCI scores from upstream to downstream seem to be closely associated to flow and dissolved oxygen levels. For this reason, analyses of results at all stations are grouped by either low flow (natural community) or high flow (point source community).

4.2.1 Natural Community: Stations #5 and #3

Stations #5 and #3 had lower MSCI scores, flow, and dissolved oxygen than the other stations. Historically, only #5 and #3 have contributed failures in the fall of 2003 and 2006. Both stations exhibited low flow and dissolved oxygen (below WQS) when these failures occurred. Neither station contains sources for continuous flow, so discharge fluctuates depending on rainfall events. Low biological support, flow, and dissolved oxygen concentrations may be a natural occurrence in these stations and the EDU. Prolonged periods of low flow are believed to be a common stressor to prairie streams in western Missouri (USEPA 2006).

Alternatively, stations #5 and #3 have passed MSCI supportability scores in spring when flow and dissolved oxygen increased. In 2004, flow at station #5 was 29.8 cfs and passed with a fully supporting MSCI score. Station #3 passed in the spring 2004 season with 52.7 cfs and, interestingly, the fall 2006 season with only 0.08 cfs. Perhaps water quality was declining due to low flow and dissolved oxygen, although the station was not yet overstressed. This alternative suggests that biological support can fluctuate due to flow and dissolved oxygen conditions.

4.2.1.2 Additional Dissolved Oxygen Studies and Comparison with Reference Stations

Additional dissolved oxygen measurements suggest that low dissolved oxygen is a common or natural occurrence in Miami Creek. Discrete dissolved oxygen measurements were recorded at #5, #3, and #1 on July 25 and 28, 2007 and ranged from 2.00 mg/L to 3.36 mg/L. This is well below the given WQS of 5.0 mg/L (MDNR 2005c). Temperatures, regardless of station or day, ranged from 23.70 to 27.24 C⁰.

Additional dissolved oxygen sampling in Little Drywood Creek indicated that low dissolved oxygen concentrations are probably typical of reference streams in the Central Plains/Osage/South Grand EDU. On September 25, 2006 dissolved oxygen was recorded at 6.42 mg/L in station #1 and 3.64 mg/L at station #2. This is consistent or slightly higher than results of continuous monitoring done at Little Drywood by Midwest Environmental Consultants (MEC 2007). Their measurements were taken between August 14 and September 13, 2006. Using long-term dissolved oxygen dataloggers, MEC found daily means that included 0.5, 3.7, 4.0, 3.5, and 2.9 mg/L at five stations on Little Drywood Creek. All means were well below the 5.0 mg/L WQS criterion. These low readings from five stations in a reference stream suggest that low dissolved oxygen levels may also reflect typical or natural conditions in streams of the Central Plains/Osage/South Grand EDU during the summer and fall months.

If low flow and, ultimately, low dissolved oxygen commonly occur in this EDU as a result of natural low flow then: 1) fluctuations in the macroinvertebrate community integrity may be a common or natural occurrence in streams of this EDU; 2) reference streams and other streams in this EDU may be threatened during periods of low precipitation; 3) WQS may need to be adjusted to reflect naturally variable conditions in streams of this and other prairie dominant EDUs; 4) Miami Creek is not continuously

impaired. In any case, additional year round and continuous long-term monitoring of dissolved oxygen should be conducted in reference streams of this and other prairie dominant EDUs in order to develop WQS that accurately reflect natural reference conditions.

4.2.2 Point Source Community: #4 and #2

Stations #4 and #2 had higher scores, flow, and dissolved oxygen. The dissolved oxygen reached WQS only at these stations. Historically, these two stations have always shown full support of the biological community and were among the highest flow and dissolved oxygen concentrations. Two point sources are apparently the reason for increased flow and dissolved oxygen at these two stations. Station #4 receives flow from one point source and #2 from another point source.

4.2.2.1 Station #4

Station #4 receives almost all of its normal low flow water from the Butler Drinking Water Treatment Facility (DWTF). A small dam just upstream of #4 and near the DWTF was once used to contain drinking water for Butler. Presently, it sometimes precludes downstream flow in Miami Creek. Water that is used by the Butler DWTF is presently pumped directly from the Marias des Cygnes to either the facility or to storage at Butler City Lake and later delivered to the DWTF. Station #4 receives its normal inflow from the DWTF discharge via a small earthen settling basin, as is required for filter backwash of chlorinated water at permitted water treatment facilities.

Several water quality constituents identify the DWTF as the upstream water source. Nitrate+nitrite-N was present in a low amount. Chloride was second highest at 51.1 mg/L. Ammonia was present at this station but may have been a remnant of higher levels found upstream or cleaning agents from the facility. Ammonia was present in the greatest concentration at station #4 in the fall of 2003, which suggests that it is a common occurrence. These constituents could be expected to occur downstream of a drinking water facility and point to the facility as their source for the increased flow. None of the indicators exceeded WQS (MDNR 2005c).

Flow from the facility is apparently related to the relatively high quality macroinvertebrate community. Station #4 had a community that was slightly more tolerant to organic pollution (BI), which suggests some possible stress. However, the BI score was too close to the optimum and other scores to confidently identify an altered community based on organic pollution. Station #4 had a nearly perfect MSCI score, which suggests that the inflow from the DWTF was within permit limits. Water quality parameters should be monitored to assure that limits of these constituents and others are within drinking water permit requirements.

4.2.2.2 Station #2

Station #2 receives its normal low flow water from the Butler Wastewater Treatment Facility (WWTF). Discharge from the WWTF enters Miami Creek from Mound Branch approximately two miles upstream from #2 (Appendix A; Attachment B). The Butler

WWTF is designed and permitted (MO-0096229) for discharge of over 27 million gallons per day through three outfalls into Mound Branch. Actual flow is much less and dependent on rainfall. Furthermore, WWTF discharge commonly contains wastewater constituents in higher concentrations.

Several of these WWTF related constituents were elevated at station #2, suggesting that the WWTF was the source for increased flow. Conductivity was 672 at station #2, over 200 uS higher than #1 downstream. Increased conductivity is commonly observed downstream of WWTFs, due to increased ion concentrations. Dissolved oxygen levels were the highest at 7.6 mg/L, perhaps a product of the oxygenation at the facility, autotrophic related oxygenation due to higher nutrient levels, or physical aeration of the increased flow in Mound Branch during transport downstream. Nitrate+nitrite-N was 4.84 mg/L, which was much higher than any other station. The concentration of total nitrogen was highest at 5.81 mg/L. Chloride, another constituent of wastewater, was at its highest concentration, nearly 30 mg/L higher than #4. No parameter exceeded WQS (MDNR 2005c). All of these constituents could be attributed to outflow from the WWTF upstream of #2 and that the flow from the WWTF was present in Miami Creek.

Point source flow at #2 apparently had a positive effect on the macroinvertebrate community. The MSCI score was perfect and intolerant taxa were prevalent, which suggested that the inflow was of relatively high quality for a period of time. Regardless, these and other water quality parameters should be monitored to assure they are maintained within acceptable limits, as outlined in the wastewater permit.

4.3 Benthic Sediment Influence

The quantity of benthic fine sediment in Miami Creek was similar between stations from upstream to downstream, as well as with the control stream. If the quantity of fine sediment observed at Little Drywood Creek control is representative of a typical high quality Central Plains/Osage/South Grand EDU stream, then Miami Creek was typical as well.

All Miami Creek stations are subject to the potential effects of row-cropping. However, local AgNPS sediment from runoff is not significantly different from the control stream. The quantity of benthic sediment has not obviously had an effect on the stream habitat quality. This suggests that Miami Creek should not be 303(d) listed for sediment related impairment.

The fine sediment sampling device developed by the WQMS (Appendix A; Attachment A) is limited in the amount of fine sediment that it can collect. It may be that the device was not capable of collecting excess quantities of fine sediment if they existed. However, the device collected similar amounts in the test and control stream, which suggested that the quantities available were similar. Also, the sampling team did not observe differences in the amount of benthic fine sediment between the control or test stations.

4.4 Channel Measurements

The Marais des Cygnes River system was the subject of an extensive channelization project that began in 1906 and was completed in 1911 (Atkenson 1918). Parts of lower Miami Creek were channelized in that effort (Dent et al. 1998). Most of the study area does not appear to have been affected by these past channelization projects. The map (Figure 2) shows that early channelization is evident mainly downstream from our most downstream station #1. In fact, Miami Creek ditch can only be considered a high water bypass and is not subject to normal base flow (MDNR 2004).

It is thought that channelized streams have less variation in depth and generally more homogenous habitat, which may not support a high quality macroinvertebrate community (AFS 1971; MDNR 2005a). Channelized streams are straighter, wider, and shallower with less variation in depth (MDNR 2005a). Using our measurements, #4 and #2 were slightly straighter than the control, whereas the remaining stations were more sinuous than the control. Overall, Miami Creek had a narrower channel and greater variation in depth than the control, indicating that it was not obviously channelized. Although the Marias des Cygnes River basin has been extensively channelized, the study area on Miami Creek was not identified as channelized using these indicators. Channelization did not have an effect on stream habitat quality.

5.0 Conclusion

Miami Creek partially supported the designated use of aquatic life protection at station #5 and fully supported the use at all remaining stations. The impairment is probably due to low flow and low dissolved oxygen. MSCI scores fluctuated from upstream to downstream and showed a relationship to flow and dissolved oxygen. Increased flow at #4 and #2 was apparently due to point sources inflow and resulted in higher MSCI scores.

An additional examination of dissolved oxygen suggested that low dissolved oxygen concentrations are either normal or common of reference streams in that EDU and possibly prairie streams in general.

The quantity of benthic fine sediment in Miami Creek was not significantly different from upstream to downstream or to the control. Using our methodology, Miami Creek was not impaired by the quantity of benthic fine sediment.

Channel morphology was not similar from upstream to downstream and to the control stream. Using our methodology, Miami Creek was not impaired due to channelization.

The objectives were met: 1) Assess the macroinvertebrate community integrity and water quality of Miami Creek; 2) Determine if benthic sediment has an affect on the stream habitat quality; 3) Determine if channelization had an affect on the stream habitat quality.

The hypotheses were examined and the following conclusions were reached:

1a) Macroinvertebrate communities were not similar from upstream to downstream due to the slight impairment of #5, which was also not similar to the BIOREFs; 1b) Dominant

families were similar from upstream to downstream, however, the percentages shifted from upstream to downstream; 2) Several physicochemical water parameters were not similar between stations; dissolved oxygen was recorded below WQS at three of the five stations including the reference; 3) An additional dissolved oxygen study in the summer showed that #5, #3, and #1 were similar to each other, did not meet WQS, and were similar to the reference stream; 4) Benthic sediment deposits were similar from upstream to downstream and to the control stream; 5) Channel morphology differed slightly from upstream to downstream, but was generally similar to the control stream.

6.0 Recommendations

- 1) Additional continuous monitoring of dissolved oxygen should be conducted at reference streams in this and other prairie dominant EDUs in order to develop WQS that accurately reflect natural reference conditions.
- 2) Water quality parameters should be monitored according to either drinking water or wastewater facility permit requirements.

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Appendix A

Missouri Department of Natural Resources
Dissolved Oxygen, Benthic Sediment, and Bioassessment Study Proposal
Miami Creek, Bates County
December 30, 2005

Missouri Department of Natural Resources
Dissolved Oxygen, Benthic Sediment and Bioassessment Study Proposal
Miami Creek, Bates County
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Background

The Miami Creek watershed originates in northwestern Bates County, near the town of Merwin, Missouri and flows southeast to its confluence with the Marais des Cygnes River. The 250 mi² watershed is mostly rural, with over 98% of the land use being comprised of cropland, pasture, and woodlands. An 18-mile segment of Miami Creek is included on the 2002 Missouri 303(d) list with the impact designated as non-point agriculture related sediment. In addition to sediment related impacts there has also been modifications to the Miami Creek channel. More than half of the lower 4.5 mi. of Miami Creek, from Highway 71 to the Marais des Cygnes River, is bracketed on one side by a levee. Miami Creek floodwater is partially captured by Miami Ditch, a 7 mi. long channel that is devoid of flow during base flow conditions. The ditch begins approximately 50 m east of the northbound lane of Highway 71 and continues southeast to the Marais des Cygnes River.

Streams subjected to increased sediment loading can be vulnerable to water quality and habitat degradations. Fertilizers and pesticides that adhere to soil particles, which are then flushed into waterways during storm events, could reduce water quality. Habitat losses can subsequently result from sediment clogging interstitial spaces in benthic structures that invertebrates use for foraging and protection. In extreme cases, sediment can affect the health of aquatic species by coating and irritating the gills of fish and invertebrates, by covering their nests and smothering eggs, and increasing the turbidity of the water thereby hindering the ability of sight feeders to forage. These potential factors have led to the placement of Miami Creek on the 303(d) List of Impaired Waters.

In 2004 a biological assessment study of Miami Creek was completed by the Field Services Division (**FSD**), Environmental Services Program (**ESP**), Water Quality Monitoring Section (**WQMS**) (MDNR 2004). As a result of that study the listed reach Stream Condition Index (**SCI**) scores for Miami Creek were determined to be below the acceptable ratio (80% / 20%) for fully biological supporting macroinvertebrate communities. The criteria used for a longer segment of stream, such as Miami Creek, is a ratio of reference stream fully supporting SCI scores to the partially and non-supporting SCI scores. The ratio for the Central Plains/Osage/South Grand Ecological Drainage Unit reference streams is 85% fully supporting to 15% partially supporting macroinvertebrate communities.

Objectives

In concordance with the MDNR Sediment TMDL Strategy, a stream listed for sediment, which does not meet the fully biological supporting criteria and has acceptable habitat, must be evaluated for water quality stressors. Therefore, we propose to conduct a re-assessment of the macroinvertebrate community of Miami Creek as well as an evaluation of channel

morphology, dissolved oxygen and benthic sediment. Dissolved oxygen is added to sediment as a potential stressor due to low levels documented during the fall 2003 sampling period. Channel morphology measurements have relationships to channel modifications and water depths, which may have associations with sediment and dissolved oxygen.

Null Hypotheses

1. The macroinvertebrate assemblages will not differ among reaches of Miami Creek from upstream to downstream.
2. Dissolved oxygen will not differ among reaches of Miami Creek from upstream to downstream.
3. Benthic sediment deposits will not significantly differ among reaches of Miami Creek from upstream to downstream.
4. Channel width, depth and sinuosity measures will not differ among reaches of Miami Creek from upstream to downstream.
5. The macroinvertebrate assemblage of Miami Creek will not differ from that found in Little Drywood Creek, a biocriteria reference stream.
6. The dissolved oxygen of Miami Creek will not differ from that found in Little Drywood Creek, a biocriteria reference stream.
7. The benthic sediment deposits of Miami Creek will not significantly differ from that found in Little Drywood Creek, a biocriteria reference stream.
8. The channel width, depth and sinuosity of Miami Creek will not differ from that found in Little Drywood Creek, a biocriteria reference stream.

Study Design

General: The Miami Creek study area is included entirely within the approximately 18 mile 303(d) listed reach of Miami Creek. The upstream boundary of the Miami Creek study area is northwest of Butler near the Butler City Lake and the downstream boundary is approximately 1 mi. upstream of Miami Creek's confluence with the Marais des Cygnes River. A total of five Miami Creek stations will be surveyed (see Attachment A for map). The general locations are listed in Table 1 beginning with the most downstream site.

Table 1
Miami Creek Sample Locations

Sample Site	Geographic Location
Miami Creek #1	S. 15; T 39 N; R 31 W
Miami Creek #2	SE ¼ S. 8; T 39 N; R 31 W
Miami Creek #3	NW ¼ S. 6; T 39 N; R 31 W
Miami Creek #4	SE ¼ S. 24; T 40 N; R 32 W
Miami Creek #5	SW ¼ S. 13; T 40 N; R 32 W

Miami Creek is in the Central Plains/Osage/South Grand Ecological Drainage Unit. Biological, chemical, and habitat comparisons will be made between the sample locations on Miami Creek and 1 site on the biological reference stream Little Drywood Creek and 2 sites on another test stream, the Little Osage River. The re-assessment of Miami Creek will take place only during the fall sampling period. This is the only season in which SCI scores were below full biological supporting in the 2004 biological assessment study. In addition, it is the season in which low dissolved oxygen values were measured.

Biological Sampling: Each macroinvertebrate station will consist of a length approximately 20 times the average stream width, and will encompass at least two pool/bend sequences. Sampling will be conducted during fall 2006 (September 15 through September 30). Macroinvertebrates will be sampled according to the guidelines of the Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2003d). Miami Creek will be considered a “glide/pool” dominated stream, with samples to be collected from depositional (non-flow), rootmat, and woody debris habitats. Macroinvertebrate samples will be a composite of six 1-m² kick samples within non-flow habitat, 6 lineal meters of rootmat habitat, and 400 cm² from each of 12 pieces of woody debris in varying stages of decomposition.

Biological samples will be collected at 5 Miami Creek stations, 1 Little Drywood Creek station and 2 Little Osage River stations.

Water Quality Sampling: Water chemistry analyses will be restricted to field measurements of dissolved oxygen and water samples for turbidity and total suspended sediment (**TSS**), which will be returned and analyzed at the ESP laboratory. The samples will be collected per the standard operating procedures: Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Considerations, MDNR-FSS-001 (MDNR 2003c) and Field Sheet and Chain-of-Custody Record, MDNR-FSS-002 (MDNR 2005a). Field measurements of dissolved oxygen will be measured per the standard operating procedures: Sample Collection and Field Analysis for Dissolved Oxygen Using a Membrane Electrode Meter, MDNR-WQMS-103 (MDNR 2002) and Continuous or Long Term Monitoring of Water Quality Using a Dissolved Oxygen and Temperature Data Logger, MDNR-WQMS-104 (MDNR 2003a).

Dissolved oxygen will be measured during a 1-month period previous to macroinvertebrate sampling (August 15 through September 15). Discrete measurements shall be taken at all sampling stations for 3 days per early morning recommendations in the Wasteload Allocation/Special Stream Studies Project Procedure (MDNR 2003e). Dissolved oxygen data loggers will be deployed at 2 Miami Creek stations, 1 Little Drywood Creek station and 1 Little Osage River station for a minimum of 3 days and a maximum of 7 days.

Turbidity and TSS samples will be collected from each sampling station once during the time period for dissolved oxygen measurements and once during the time period for macroinvertebrate sampling. Stream discharge measurements also will be taken at the time of sample collection using a Marsh-McBirney flow meter per MDNR-FSS-113 (MDNR 2003b).

Draft Benthic Sediment Sampling: Benthic sediment will be measured once during the fall low flow period at all sampling stations. See Attachment A for sampling method.

Channel Morphology Measurements: The ESP has selected stream reach and channel measurements that tend to represent undesirable changes in channel morphology due to channel modifications. Those measurements are Average Channel Width, Average Wetted Channel Width, Ratio of Channel Width to Wetted Width, Average Depth, Ratio of Wetted Width to Depth, Drainage Size, Sinuosity, the Standard Deviation of Depth, and Maximum Depth.

At each sampling station a series of 10 bank to bank transects will be established. Each transect is equally spaced within the sampling reach. Each spacing is equivalent to 20x the average width. Channel measurements are taken at each transect. These measurements included lower bank width, wetted width, and water depth at $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ of the distance across the wetted width. In order to document critical habitat conditions, measurements will be collected once during the fall low flow period.

Laboratory Methods: All water quality samples will be analyzed at the MDNR ESP laboratory. The samples of macroinvertebrates will be processed (MDNR 2003d) and identified per the standard operating procedure Taxonomic Levels for Macroinvertebrate Identification, MDNR-FSS-209 (MDNR 2005b).

Data Recording and Analyses: Macroinvertebrate data will be entered in a Microsoft Access database in accordance with Quality Control Procedures for Data Processing, MDNR-WQMS-214 (MDNR 2003f). Data analysis is automated within the Access database. A total of four standard metrics will be calculated for each sample reach according to the SMSBPP: Taxa Richness (TR); Ephemeroptera, Plecoptera, Trichoptera Taxa (EPTT); Biotic Index (BI); and the Shannon Diversity Index (SDI). Additional metrics, such as Quantitative Similarity Index for Taxa (QSI-T) may be used to discern differences in taxa between control and impacted stations.

Macroinvertebrate data will be analyzed in two specific ways. First, a comparison of metrics will be made between sample reaches on Miami Creek upstream and downstream of potential influences (e.g. confluence with Mound Branch, the receiving system for the Butler Wastewater Treatment Facility). Second, Miami Creek data will be compared to that collected at Little Drywood Creek and Little Osage River.

Ordination of macroinvertebrate data may be performed and regression analysis used to examine potential associations with water chemistry and habitat data. Benthic sediment, channel morphology and water quality data also will be used to help interpret macroinvertebrate data.

Water quality data will be entered in the Laboratory Information Management System (LIMS) database. Data analysis will be summarized and interpreted using Microsoft Access and Excel software as well as Jandel Scientific software, SigmaStat.

Data Reporting: Results of the study will be summarized and interpreted in report format.

Quality Control: As stated in the various MDNR Project Procedures and Standard Operating Procedures.

Literature Cited

Missouri Department of Natural Resources. 2002. Sample Collection and Field Analysis for Dissolved Oxygen Using a Membrane Electrode Meter. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 13 pp.

Missouri Department of Natural Resources. 2003a. Continuous or Long Term Monitoring of Water Quality Using a Dissolved Oxygen and Temperature Data Logger. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 25 pp.

Missouri Department of Natural Resources. 2003b. Flow Measurements in Open Channels. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 9 pp.

Missouri Department of Natural Resources. 2003c. Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Considerations. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 21 pp.

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Missouri Department of Natural Resources. 2003e. Wasteload Allocation/Special Stream Studies Project Procedure. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 9 pp.

Missouri Department of Natural Resources. 2003f. Quality Control Procedures for Data Processing. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 6 pp.

Missouri Department of Natural Resources. 2004. Biological Assessment Report, Miami Creek, Bates County. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 23 pp.

Missouri Department of Natural Resources. 2005a. Field Sheet and Chain-of-Custody Record. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 8 pp.

Missouri Department of Natural Resources. 2005b. Taxonomic Levels for Macroinvertebrate Identification. Field Services Division, Environmental Services Program. Water Quality Monitoring Section, P.O. Box 176, Jefferson City, Missouri, 65102. 30pp.

Attachments

Attachment A: Draft Benthic Sediment Sampling Method

Attachment B: Maps

Attachment A

Draft Benthic Sediment Procedure

Sediment should increase from upstream to downstream due to naturally occurring events such as bank and streambed erosion and runoff from tributaries experiencing bank and streambed erosion. When human disturbance takes place in a watershed (increased impervious area, increased magnitudes during flood events, removal of vegetation from land in the watershed, channel modification, etc.) the amount of sediment available for transport in a stream should increase through increased erosion rates. Given similar watershed characteristics (geology, land cover, etc.) two streams should contain (in their bed-loads) similar quantities and types of sediment (sand and silt).

Potential Study Questions

Are the amounts of sediment (silt + sand), only silt, and only sand, increasing from upstream to downstream in the test stream by an amount similar to the control stream?

Are the amounts of sediment (silt + sand), only silt, and only sand, different between the test stream and control stream? Are they higher or lower?

Procedures

Multiple sites along a longitudinal gradient should be sampled. Sites can also bracket locations that could possibly contribute to increased sediment inputs to a test stream. Upstream and downstream coordinates should be collected using handheld Global Positioning System units.

Benthic Sediment Sampling Device

At each site twenty composite samples are collected. Each sample will be a composite of four grabs taken from a transect. The grabs will be collected using a device created by the Water Quality Monitoring Section (Figure 1). The device is composed of two main parts, the handle and sample cup assembly and the outer casing, which slide vertically and independently of each other. The handle and sample cup assembly are composed of a threaded rod approximately 36 inches long with a wooden handle attached to the top and a PVC sample cup, oriented with the opening upwards, attached to the bottom. The exposed portions of threaded rod, not covered by the handle or the sample cup, are covered with rubber tubing to reduce friction when sliding vertically through the casing and to minimize any water that may splash upward through the casing assembly. The inside dimensions of the sample cup are $3\frac{1}{4}$ inches diameter by $1\frac{1}{2}$ inches tall. This yields a volume of approximately 12.44 in^3 . The outer casing is composed of a 6 inch long piece of 4 inch inner diameter (ID) PVC attached to a 24 inch long piece of $\frac{3}{4}$ inch ID PVC in which the handle and sample cup assembly can slide vertically. At the top of the 4 inch ID PVC, and on the inside, is a rubber seal to help contain the sample until it can be emptied into the collection container.

Each grab sample is obtained in the following manner. First, the handle/sample cup assembly is slid upwards until the sample cup contacts the rubber seal. Then, the device is lowered into the

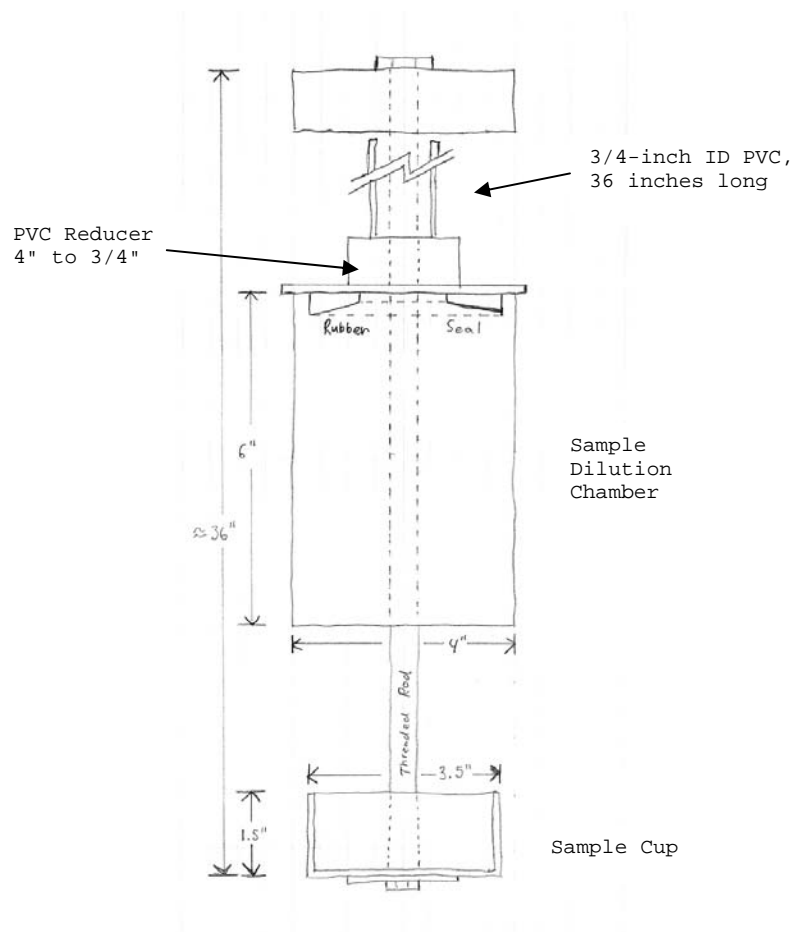


Figure 1

water until it contacts the stream bottom taking care to ensure the best seal possible between the PVC casing and the stream bottom. The depth of water must be at least six inches to ensure that the entire section of 4-inch ID PVC is filled with water. The handle and sample cup assembly are then pushed downward until the sample cup contacts the stream bottom, and then pulled upward until the sample cup contacts the rubber seal again in one motion. This is done five times, taking approximately 1 second each, resulting in the mixing of sediment on the stream bottom with the water trapped in the 4 inch ID PVC casing sample chamber.

After the fifth time water and sediment are trapped in the sample cup by exerting upward pressure on the handle. The device is removed from the water making sure the device is kept vertical with the handle at the top and the sample cup at the bottom to maintain a sealed sample. The sample cup is then gently lowered to its lowest extent and removed by holding the sample cup stationary and turning the handle counter-clockwise. This results in the sample cup being unscrewed from the threaded rod. This is best accomplished by two people to minimize spillage from the sample cup. The contents of the sample cup are then poured into a collection container, which, for the purposes of this study, will be a one-quart glass or

plastic container. Any remaining sediment should be gently washed from the sample cup into the collection container with deionized water.

Sample Collection

As mentioned above, twenty composite samples will be collected at each of the six sites. A composite sample will consist of four grab samples collected at a transect. The transect spacing will be determined by the average width of the stream over the sampling reach. (*For procedures regarding determination of the average stream width see the Missouri Department of Natural Resources, Stream Habitat Assessment Project Procedure.*) At each transect a tape measure will be stretched over the width of the stream, including eddies or pools connected to the stream on the backside of point bars. Four grab samples are to be collected at each transect resulting in a composite sample. The outer points of the tape measure where the water reaches six inches deep will be noted (Figure 2). These are the two outer grab sample points. If the water is too shallow to establish the outer points or the distance between the two points will not allow the collection of four grab samples the transect shall be moved upstream until a suitable transect can be established.

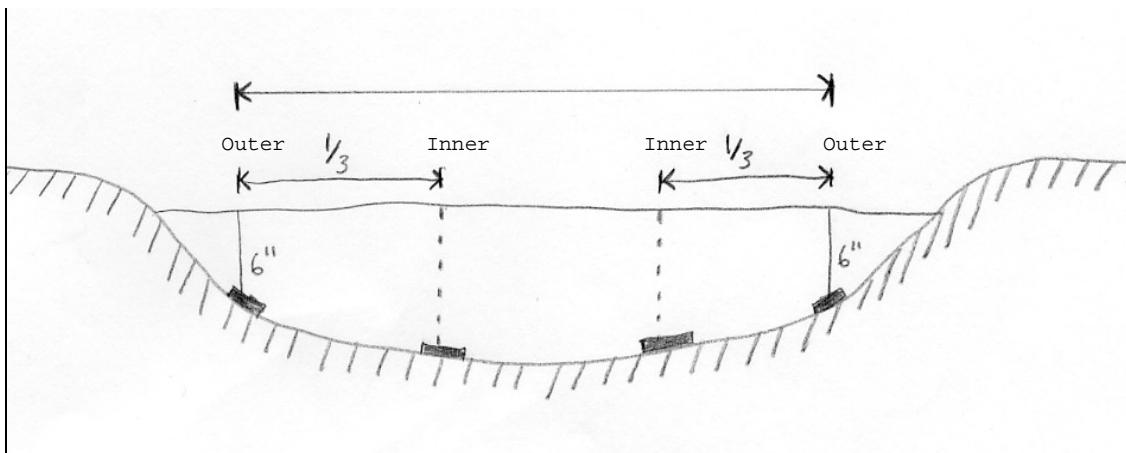


Figure 2

A suitable transect must be at least 6-inches deep and wide enough over that depth to collect four grab samples (16 inches wide). If the water is deep enough, the remaining distance between the two outer points will be divided into thirds (Figure 2). The distance to each third will be noted along with the two points where the water reaches six inches deep. These are the two inner grab sample points. If either of the "inner" points lies on an isolated obstruction (boulder, log, etc.) that is submerged or partially submerged, leaving less than six inches of water, (Figure 3) the transect will be moved upstream to a point where the obstruction does not interfere with the survey. If either of the "inner" points lies on a point bar above the water level (Figure 4, Point A), or on the slope of a point bar in water less than six inches deep (Figure 4, Point B), the following will occur:

1. Find a location, moving towards the nearest "outer" point where the water is at least six inches deep (Figure 4, Point C).

2. Measure the distance between this new point and the nearest "outer" point.
3. Move one-third this distance toward the "outer" point (Figure 4, Point D).
4. This will be the new "inner" point.

At this time there should be four grab sample points established. Using the sampler, gather sediment sample from each point and composite them in a sample container. When all twenty transects have been completed there will be 20 samples per site, which have been collected from 120 individual benthic locations.

Additional information to be recorded at each transect includes: type of sampling habitat (riffle, run or pool); width between outer sampling points; and, general observation of bank conditions (i.e. denuded, vegetated, slumping, etc). Discharge will be surveyed at each sampling site.

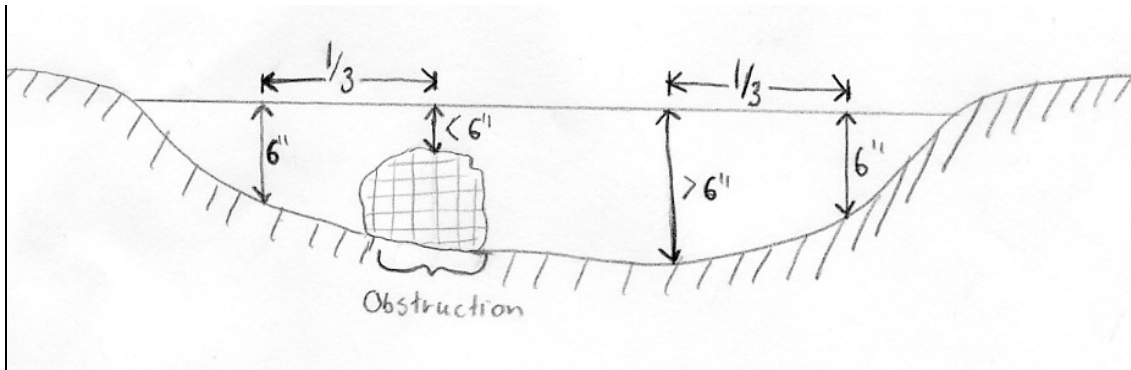


Figure 3

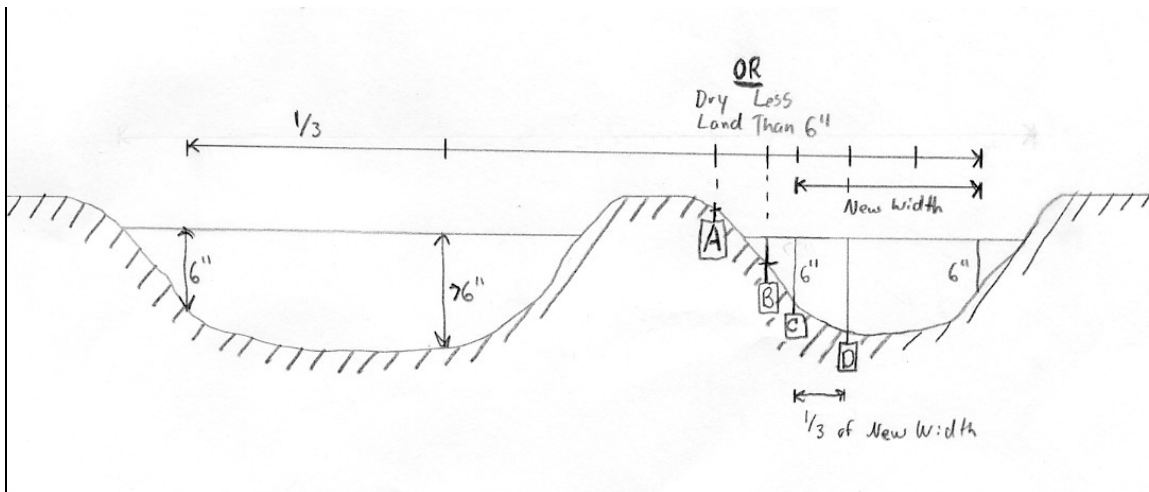


Figure 4

Settling Tube Sample Analysis

Modifying the Bouyocos Soil Texture Method for Sediment Analysis

The determination of soil texture is called: 1) particle size analysis or 2) mechanical analysis. Determining the texture in the laboratory uses a basic principle of sedimentation called "Stokes Law". Stokes Law states that the speed or velocity with which particles settle out of a liquid medium is dependent on a constant factor (K) and the radius of the particles. Or, the bigger the particle, the faster it will fall out of suspension. K is composed of the factors:

g = acceleration of gravity

d_1 = density of particle

d_2 = density of liquid

μ = viscosity of liquid

v = velocity

$v = Kr^2$, and $K = 2g(d_1 - d_2) \div \mu$

An approximation of the formula is $v \text{ (cm/sec)} = 8711d^2 \text{ (cm)}$

The same method that is used for soil analysis can be used on sediment found in streams and rivers. Major sediment fractions of concern are sands and silts. Both can cause the loss of interstitial spaces in gravel and cobble bottom streams or change the benthic deposits composition of streams with naturally finer materials making up the streambed. The Bouyocos method is useful in separating coarse through fine sand from very fine sands through silt. The Wentworth soil particle scale is useful in defining the diameters of these particles. The upper limit for sand is a diameter of 0.2 cm and the lower limit for fine sand is 0.0125 cm. The upper limit for very fine sand is <0.0125 cm.

The standard Bouyocos method uses a Hydrometer jar (ASTM D-422). The jar is a glass cylinder with dimensions of 6.4 cm outside diameter by 45.7 cm vertical distance to a calibrated white line which is the beginning point of measurement. The basic principal applied is the settling velocity of particular diameter particles. The initial reading is taken with a hydrometer at 40 seconds with a secondary reading at 2 hours. The 40 second reading is the time which most particles of fine sand (>0.0125 cm) have reached the bottom. The 2-hour reading the time at which most silt particles (0.0124 – 0.0004 cm) have reached the bottom. Any material in suspension after two hours is considered the clay fraction.

The modified method uses a different tube length and direct sediment measurement instead of hydrometer readings. The sedimentation tubes are 6 cm outside diameter by 60 cm long clear PVC plastic tubes with PVC plugs in one end. The calibration mark is at 55.5 cm. If the 45.7 cm hydrometer jar's first reading is made at 40 seconds then the 55.5 cm settling tubes can be algebraically solved for the adjusted first reading. The adjusted time for a longer settling distance at the first reading is approximately 48 seconds.

Sediment Analyses Method

The samples will be refrigerated and allowed to settle at least two hours or until a sample can be analyzed. There is no holding time for these samples, although they should be refrigerated. Prior to analysis each sample will be allowed to sit at least two hours to warm up to room temperature. Each sample will be analyzed in the lab using Settling Tube analysis as follows.

Assuming the sample has been allowed to settle at least two hours, any free water in the container can be poured off gently not allowing any settled sediment to be released from the container. The remaining sediment and water are transferred to a 24-inch long piece of 2-inch ID clear PVC through a 2-millimeter filter to exclude particles greater than 2 millimeter. The PVC is capped at the bottom to contain the sample in the pipe. The PVC should then be filled with water to exactly 2 inches from the top, which allows a small amount of air space. The PVC is then temporarily capped with a rubber stopper and inverted five times, allowing the bubble to move entirely from one end to the other, mixing the sediment and water completely.

After the fifth time the tube is set into the analysis rack and a stopwatch is started immediately. After 45 seconds the depth of sediment is measured in the tube from the bottom of the tube to the top of the settled sediment. This is done with a flat metal ruler graduated in millimeters. Forty-five seconds is the amount of time for most sand particles to settle out and shall be referred to as the "45 second reading." The depth is recorded on the standard data sheet (see attachment A).

The sediment is then allowed to settle for two hours. At that time two sets of measurements are taken. The first measurement is the total amount of settled sediment and is measured like the "45 second reading." The second measurement is an approximation of the interface between the coarse sand and finer particles. This interface is approximately equal to the depth of sediment recorded after 45 seconds, and should be readily apparent. If it is not apparent, the analyst should measure the approximate interface between sand and finer particles, if that interface exists. If the sample is composed entirely of sand (no apparent interface) the entire depth is measured. If the sample is composed entirely of finer particles (the 45 second reading reveals no settled sediment) the interface reading is zero. The tube must then be turned 180 degrees and both readings taken again as above. This will result in two sets of readings: two readings of total sediment and two readings of the sand/finer particle interface. Each set of readings is averaged to result in a final reading (see Attachment A). The sand/finer particle interface reading is subtracted from the total sediment reading to result in the amount of finer particles (fine sand and silt). Five samples can be analyzed at the same time using the sediment tube rack (Figure 3).

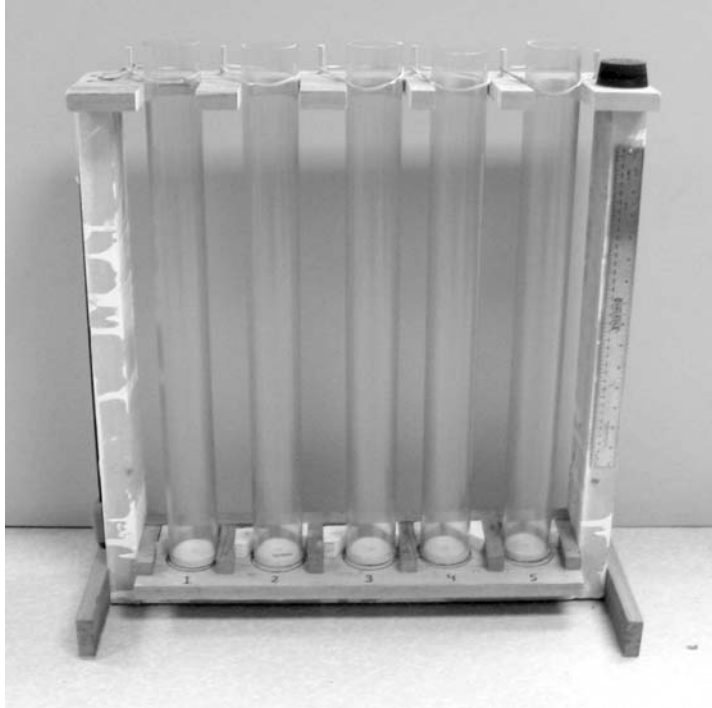


Figure 5

Data Analysis and Final Reporting

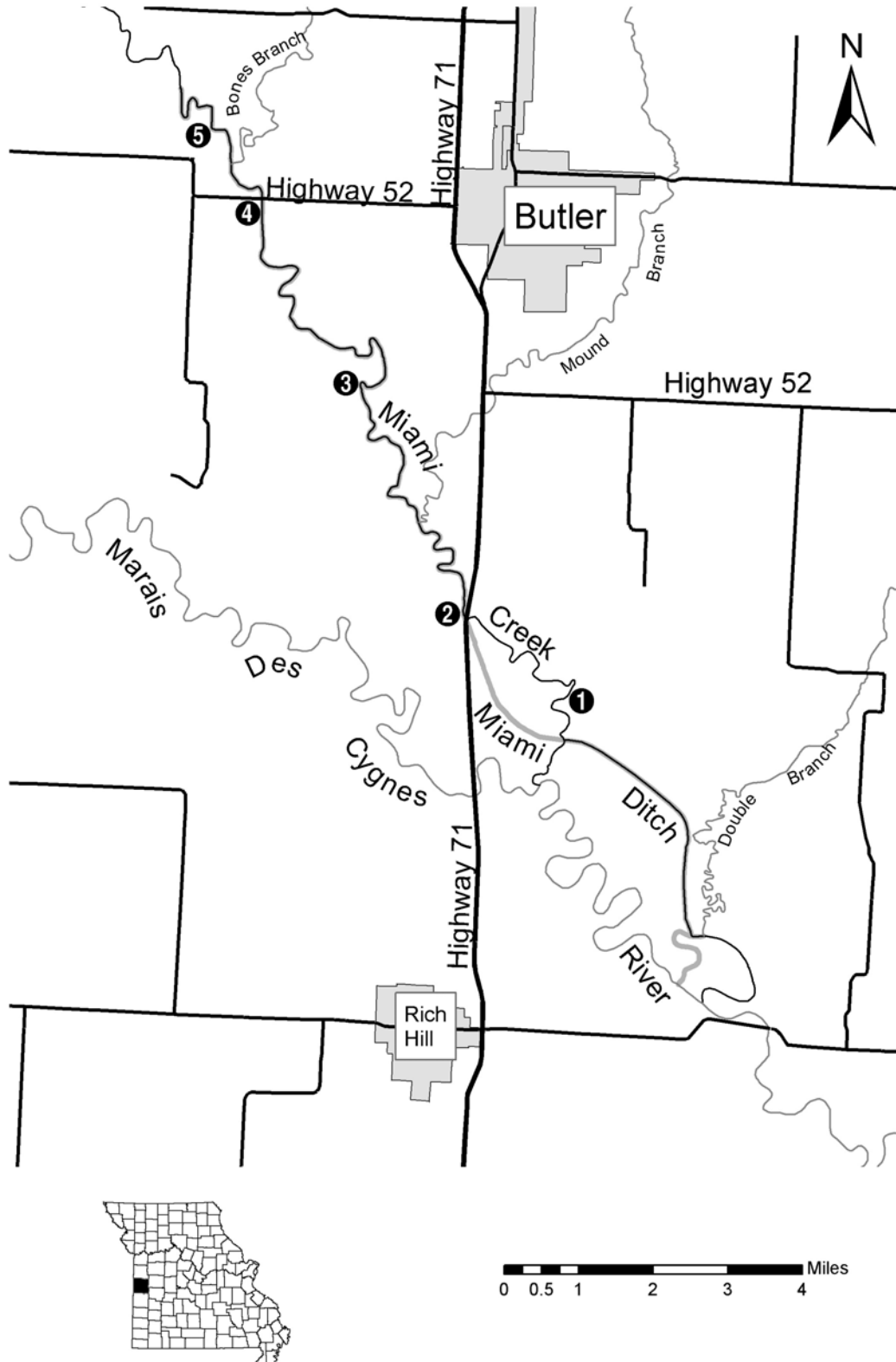
Data will be analyzed for differences between test stream and control stream for changes in amounts of sediment from upstream to downstream and differences in amounts of sediment between streams. These differences will include only sand, only silt and silt and sand combined. For the first objective the changes in amounts of sediment from upstream to downstream, between each station, will be calculated. These differences will be compared to the control stream using box plots and Analysis of Variance to detect significant differences. For the second objective, raw measurements of amounts of sediment for each station will be compared to the stations at the control stream for significant differences using box plots and Analysis of Variance.

Attachment B

Maps

Miami Creek

Bates County, Missouri
Bioassessment Sampling Stations



Appendix B

Invertebrate Database Bench Sheet Report for Miami Creek, Bates County
Fall 2006

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602745], Station #5, Sample Date: 10/4/2006 7:55:00 AM****NF = Nonflow; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	SG
"HYDRACARINA"		
Acarina	29	28
AMPHIPODA		
Hyaella azteca		73
ARHYNCHOBDELLIDA		
Erpobdellidae	-99	
COLEOPTERA		
Neoporus		1
Scirtidae		14
DIPTERA		
Ceratopogoninae	37	1
Chaoborus	1	
Chironomus		2
Cladopelma	21	
Clinotanypus		1
Dicrotendipes	3	212
Diptera	1	
Einfeldia	2	
Glyptotendipes		2
Kiefferulus		7
Paratendipes	1	
Polypedilum halterale grp	1	
Procladius	18	1
Tanypus	33	2
Tanytarsus	81	21
EPHEMEROPTERA		
Caenis latipennis	7	77
Callibaetis		2
Leptophlebiidae		1
HEMIPTERA		
Corixidae	1	
LIMNOPHILA		
Ancylidae		3
Fossaria		-99
Helisoma		-99
Physella	1	-99
Planorbella		-99
MEGALOPTERA		
Sialis	2	
ODONATA		

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602745], Station #5, Sample Date: 10/4/2006 7:55:00 AM****NF = Nonflow; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	SG
Epicordulia	-99	
Somatochlora	1	
RHYNCHOBDELLIDA		
Glossiphoniidae	1	1
TUBIFICIDA		
Aulodrilus	1	
Branchiura sowerbyi	49	1
Ilyodrilus templetoni	7	
Quistradrilus multisetosus	15	31
Tubificidae	33	2
VENEROIDEA		
Sphaeriidae	25	2

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602750], Station #4, Sample Date: 10/4/2006 3:20:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	6	5	1
AMPHIPODA			
Hyaella azteca	1	34	49
COLEOPTERA			
Dubiraphia		2	
Neoporus			2
Scirtidae	1	50	2
DECAPODA			
Palaemonetes kadiakensis		1	
DIPTERA			
Ablabesmyia			1
Anopheles	1	1	
Ceratopogoninae	9	2	3
Chironomus	22		
Cladotanytarsus	2		
Clinotanypus	1		
Corynoneura	1	1	
Cricotopus/Orthocladius		1	
Cryptochironomus	2		
Cryptotendipes	7		
Culex		1	
Dicrotendipes	3	18	78
Glyptotendipes		29	21
Hydrobaenus		1	
Limonia			1
Microchironomus	1		
Microtendipes	4		5
Nanocladius		3	
Parachironomus		1	
Parakiefferiella			1
Paratanytarsus		1	
Polypedilum halterale grp	2		
Polypedilum illinoense grp	20	7	8
Procladius	19		3
Stenochironomus			1
Tanypus	2		
Tanytarsus	16	29	28
Thienemannimyia grp.		2	7
Tribelos	46	7	46

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602750], Station #4, Sample Date: 10/4/2006 3:20:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
undescribed Empididae	1		
EPHEMEROPTERA			
Caenis latipennis	27	56	32
Callibaetis	1	2	3
Leptophlebiidae		3	1
Stenacron		7	1
Stenonema femoratum		2	
HEMIPTERA			
Belostoma		1	
Neoplea		2	
Ranatra buenoi		-99	
Ranatra kirkaldyi		-99	
LIMNOPHILA			
Ancylidae	1	1	
Helisoma			-99
Lymnaeidae	1		
Menetus		5	2
Physella	1	33	1
ODONATA			
Argia		11	4
Enallagma		11	1
Ischnura		1	
Nasiaeschna pentacantha		-99	
RHYNCHOBDELLIDA			
Glossiphoniidae	2	2	1
TRICHOPTERA			
Cernotina		2	
Cynellus fraternus			5
Hydropsychidae	1		
Hydroptila			1
Oecetis	3	2	2
Orthotrichia			1
TRICLADIDA			
Planariidae		1	1
TUBIFICIDA			
Aulodrilus	7		1
Branchiura sowerbyi	5		
Ilyodrilus templetoni	9		
Quistradrilus multisetosus	46		2
Tubificidae	21	1	6

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602750], Station #4, Sample Date: 10/4/2006 3:20:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
VENEROIDEA			
Corbicula			2
Sphaeriidae	9		4

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602749], Station #3, Sample Date: 10/4/2006 2:00:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
"HYDRACARINA "			
Acarina	25	10	21
AMPHIPODA			
Hyaella azteca		119	15
ARHYNCHOBDELLIDA			
Erpobdellidae	1		
COLEOPTERA			
Copelatus		-99	
Dubiraphia		1	
Paracymus			1
Peltodytes	1		
Scirtidae		31	1
DECAPODA			
Orconectes virilis		1	
Palaemonetes kadiakensis		-99	
DIPTERA			
Ablabesmyia	1		
Anopheles		1	
Ceratopogoninae	14	1	1
Chaoborus	9		
Chironomus	26	1	4
Cladopelma	14		
Cladotanytarsus	1		1
Clinotanypus	3		2
Cricotopus bicinctus	1		
Cryptochironomus	3		
Culex		1	
Dicrotendipes	15	87	170
Forcipomyiinae		1	1
Glyptotendipes	4	30	46
Goeldichironomus			1
Kiefferulus	9	25	16
Parachironomus		1	2
Paraphaenocladus	1		
Paratanytarsus		1	
Polypedilum halterale grp	1		
Polypedilum illinoense grp	3		
Polypedilum scalaenum grp			1
Procladius	55		3
Tanypus	14		2

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602749], Station #3, Sample Date: 10/4/2006 2:00:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
Tanytarsus	17		3
Thienemannimyia grp.			1
Tribelos		4	16
EPHEMEROPTERA			
Caenis latipennis	1	9	6
Callibaetis	1	5	1
Hexagenia limbata	-99		
Leptophlebiidae	1	6	2
Stenacron	2	13	1
HEMIPTERA			
Corixidae	10	3	3
ISOPODA			
Lirceus		1	
LIMNOPHILA			
Ancylidae			1
Physella	1	20	3
Planorbella			-99
MEGALOPTERA			
Chauliodes rastricornis		-99	
Sialis	2	-99	-99
ODONATA			
Argia		3	
Enallagma		5	
Gomphus	-99		
Ischnura	1		
Libellulidae		1	-99
Nasiaeschna pentacantha		1	
TRICHOPTERA			
Cernotina		1	
TUBIFICIDA			
Aulodrilus	4		1
Branchiura sowerbyi	14	1	
Ilyodrilus templetoni	12		
Quistradrilus multisetosus	21		3
Tubificidae	82		1
UNIONIDA			
Unionidae	-99		
VENEROIDEA			
Sphaeriidae	10		12

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602748], Station #2, Sample Date: 10/4/2006 12:30:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
"HYDRACARINA "			
Acarina	2		7
AMPHIPODA			
Crangonyx	1	4	
Hyaella azteca	2	104	47
ARHYNCHOBDELLIDA			
Erpobdellidae	6	5	
COLEOPTERA			
Berosus	8	2	7
Dubiraphia		11	1
Neoporus		1	
Peltodytes	1		
Scirtidae			5
Stenelmis	3		
DECAPODA			
Palaemonetes kadiakensis		2	
DIPTERA			
Ablabesmyia	1	5	1
Anopheles		1	
Ceratopogoninae	7	1	1
Chironomus	6		2
Cladotanytarsus	1		
Corynoneura	3	6	
Cricotopus bicinctus	2	3	3
Cryptotendipes	1		
Dicrotendipes	4		31
Forcipomyiinae	2		1
Glyptotendipes		7	5
Kiefferulus	1		
Labrundinia	1		
Microtendipes	2		3
Parachironomus		1	
Paratanytarsus		1	
Polypedilum illinoense grp	4	24	3
Polypedilum scalaenum grp	3		1
Procladius	22	1	10
Pseudochironomus			2
Rheotanytarsus		5	
Stenochironomus			5
Tanypus	5		3

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602748], Station #2, Sample Date: 10/4/2006 12:30:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
Tanytarsus	11	23	30
Thienemannimyia grp.	6	7	12
Tribelos	1		20
EPHEMEROPTERA			
Caenis latipennis	37	9	36
Callibaetis			3
Hexagenia limbata	-99		1
Proclleon			1
Stenacron	16	2	8
Stenonema femoratum	2		4
Tricorythodes		1	1
HEMIPTERA			
Corixidae			1
Neoplea		2	
Ranatra fusca		-99	
ISOPODA			
Lirceus	1	6	
LIMNOPHILA			
Ancylidae	3		
Helisoma	-99		
Lymnaeidae	3		3
Menetus	1	6	1
Physella	2	14	1
LUMBRICULIDA			
Lumbriculidae	1		
ODONATA			
Argia	1	20	5
Enallagma		2	
RHYNCHOBDELLIDA			
Glossiphoniidae		1	
TRICHOPTERA			
Cheumatopsyche	4	3	
Hydroptila		1	2
Leptoceridae			3
Oecetis	5		1
TRICLADIDA			
Planariidae	20	1	
TUBIFICIDA			
Aulodrilus	5		1
Ilyodrilus templetoni	2		

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602748], Station #2, Sample Date: 10/4/2006 12:30:00 PM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
Quistradrilus multisetosus	25		5
Tubificidae	18	4	5
VENEROIDEA			
Corbicula	43		27
Sphaeriidae	32		4

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602746], Station #1a, Sample Date: 10/4/2006 10:00:00 AM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	10		2
AMPHIPODA			
Crangonyx		21	1
Hyaella azteca	4	7	14
COLEOPTERA			
Berosus	5	11	7
Dubiraphia	1	14	1
Hydroporus		2	
Scirtidae		3	4
Stenelmis			1
DIPTERA			
Ablabesmyia	3	6	8
Ceratopogonidae	9	2	1
Chironomus	4		1
Cladotanytarsus	4		
Corynoneura		1	
Cricotopus/Orthocladius		1	
Cryptochironomus	4		
Cryptotendipes	3	1	
Culicidae			1
Dicrotendipes	32	19	50
Forcipomyiinae			3
Glyptotendipes	1	2	2
Hexatoma			1
Limonia			1
Microtendipes		1	3
Paralauterborniella	1		
Paraphaenocladius			1
Paratendipes	1		
Polypedilum	1		
Polypedilum convictum		2	
Polypedilum illinoense grp			4
Procladius	26	1	5
Rheotanytarsus		5	
Stempellinella			1
Stenochironomus		1	3
Tanytarsus	24	9	29
Thienemannimyia grp.	1	6	1
Tribelos		7	12

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602746], Station #1a, Sample Date: 10/4/2006 10:00:00 AM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
EPHEMEROPTERA			
Acerpenna			1
Caenis latipennis	68	6	27
Hexagenia limbata	4		3
Proclonon	2		1
Stenacron			17
Stenonema femoratum			1
HEMIPTERA			
Corixidae	12	4	1
Trichocorixa	1		
ISOPODA			
Lirceus	1		
LIMNOPHILA			
Ancylidae	5	1	6
Fossaria		2	
Helisoma	-99		1
Menetus	7	32	6
Physella	10	1	2
Planorbella			1
ODONATA			
Argia		47	12
Enallagma		1	
Erythemis		1	
Libellulidae	3		1
Macromia	-99		
RHYNCHOBDELLIDA			
Glossiphoniidae	5	1	3
TRICHOPTERA			
Cheumatopsyche		3	43
Hydroptila	1	1	3
Oecetis	26	1	2
TRICLADIDA			
Planariidae	3	8	8
TUBIFICIDA			
Limnodrilus hoffmeisteri	2		
Quistadrilus multisetosus	11	13	23
Tubificidae	10	11	15
VENEROIDEA			
Corbicula		6	4
Sphaeriidae	18	31	31

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602747], Station #1b, Sample Date: 10/4/2006 10:00:00 AM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	10	2	2
AMPHIPODA			
Crangonyx		41	
Hyaella azteca	8	17	8
COLEOPTERA			
Berosus	2	8	8
Coleoptera			1
Dubiraphia	1	6	1
Hydrochus			1
Neoporus	1	2	1
Scirtidae		5	1
Tropisternus		-99	
DECAPODA			
Orconectes virilis		-99	
Palaemonetes kadiakensis		-99	
DIPTERA			
Ablabesmyia	1	3	3
Ceratopogoninae	11		
Chironomus	5		
Cladotanytarsus	6		3
Corynoneura		2	1
Cricotopus bicinctus		2	
Cryptotendipes	3		
Dicrotendipes	25	8	50
Forcipomyiinae			1
Labrundinia		2	
Microtendipes		7	2
Paralauterborniella			1
Paratanytarsus			1
Polypedilum convictum			2
Polypedilum halterale grp			1
Polypedilum illinoense grp	1	4	3
Polypedilum scalaenum grp	1		6
Procladius	30	1	10
Rheotanytarsus	3	7	3
Stenochironomus			8
Tanypus	8		
Tanytarsus	44	8	35
Thienemanniella			1

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602747], Station #1b, Sample Date: 10/4/2006 10:00:00 AM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
Thienemannimyia grp.	1	4	8
Tribelos		1	6
EPHEMEROPTERA			
Acerpenna			4
Caenis latipennis	86	9	19
Callibaetis	1	1	
Hexagenia limbata	3	1	3
Procloeon	2		2
Stenacron		3	14
Tricorythodes			2
HEMIPTERA			
Corixidae	19		3
Gerridae	1		
Mesovelgia		1	
Pelocoris		1	
Trichocorixa	2		
ISOPODA			
Lirceus		1	
LIMNOPHILA			
Ancylidae	7	1	9
Helisoma	-99		-99
Lymnaeidae	2	1	1
Menetus	5	37	9
Physella	2	6	3
Planorbella	1		2
LUMBRICULIDA			
Lumbriculidae		3	
ODONATA			
Argia		94	5
Dromogomphus	-99		
Macromia	-99		-99
Somatochlora	-99		
RHYNCHOBDELLIDA			
Glossiphoniidae	10	-99	1
TRICHOPTERA			
Cheumatopsyche			20
Hydrotilla	1		
Oecetis	50	1	2
TRICLADIDA			
Planariidae	3	6	6

Aquid Invertebrate Database Bench Sheet Report**Miami Ck [0602747], Station #1b, Sample Date: 10/4/2006 10:00:00 AM****NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence**

ORDER: TAXA	NF	RM	SG
TUBIFICIDA			
Aulodrilus	10	3	
Branchiura sowerbyi	1		2
Ilyodrilus templetoni	7		
Limnodrilus hoffmeisteri	1		
Quistradrilus multisetosus	16	5	3
Tubificidae	14	1	9
UNIONIDA			
Unionidae	-99		-99
VENEROIDEA			
Corbicula	-99	1	15
Sphaeriidae	24	20	47

Appendix C

One Way Analysis of Variance (ANOVA)
on Benthic Sediment Deposits Between Stations on
Miami Creek and Little Drywood Creek (LDWC)

Data source: Benthic Fine Sediment per Station

Normality Test: Passed (P = 0.043)

Equal Variance Test: Passed (P = 0.281)

Group Name	N	Missing	Mean	Std Dev	SEM
LDW1	11	0	132966.145	50370.960	15187.416
5.000	11	0	167496.827	70437.379	21237.669
4.000	11	0	180019.955	123042.205	37098.621
3.000	11	0	104973.273	52521.131	15835.717
2.000	11	0	150553.773	73978.145	22305.250
1.000	1	0	130295.773	64667.573	19498.007

Source of Variation	DF	SS	MS	F	P
Between Groups	5	40966652211.953	8193330442.391	1.403	0.236
Residual	60	350511723930.442	5841862065.507		
Total	65	391478376142.395			

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.236).

Power of performed test with alpha = 0.050: 0.145

The power of the performed test (0.145) is below the desired power of 0.800. You should interpret the negative findings cautiously.

Note: Group Name=Stations; LDW=Little Drywood Creek; measures=mm³